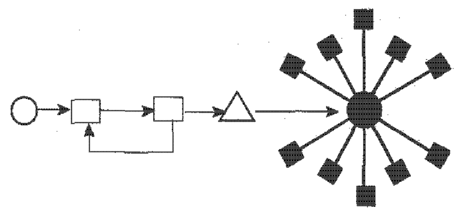
INTERMOUNTAIN POWER SERVICE CORPORATION



# DCS Replacement Project

## Master Plan

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# EXECUTIVE SUMMARY: DCS Systems Status and Future

Overview
The DCS Replacement Project Working Group was assigned to review the status of existing control and process data systems at the Intermountain Generating Station (IGS) and develop recommendations to ensure the long term viability of control system functions. The findings of this review are found in this document.

Included Systems
1. **Process Data Systems**
   a. FOX 1/A computer systems
   b. Plant Data Systems: PI Plant Information Systems
2. **Process Control Systems**
   a. Foxboro Videospec and Microspec systems
   b. GE Turbine Automatic Controls (TAC), Turbine-Generator Supervisory Instrumenation (TGSI), Electro-Hydraulic Control (EHC), and the MDT20 BFPT Control systems
   c. Rochester Information System (RIS)
   d. Bailey burner control systems.
3. **IGS Controls Simulator** - Training and Controls Testing System

Status & Condition
The primary concerns facing the plant process data and control systems are obsolescence and lack of expansion capacity.

The FOX 1/A systems are experiencing increasing levels of failure and difficulty in obtaining replacement components. While the impact of these failures has been minimized to date, system trends are towards increased rates of failure. Decreasing system reliability is likely to have an increased impact on unit operation.

The PI system uses newer technology. Obsolescence and spare parts availability are not currently problems, but there is some indication of upcoming issues in these areas on the primary server, PI-Home. Long range plans are in place to meet those concerns through the PI Migration Project. Investigation was made into the possibility of consolidation of PI functions with a future DCS system. However, current DCS systems do not adequately provide the historian and analysis capabilities of PI. Continuation of PI as a separate, plant wide system is recommended.

The Foxboro, Bailey, and Rochester control systems are still operating reliably. Some problems with spare parts availability have been encountered and solved. However, these systems are the same generation of equipment as the FOX 1/A systems, and it is expected that the problems currently experienced on the FOX 1/A systems are a precursor to the future on the control systems.

The General Electric (GE) turbine controls systems are currently experiencing failure and reliability problems with TAC systems most affected. Increasing failure and reliability problems are expected on these systems.

IGS currently has no simulator system for training or controls testing.

Proposed Replacement Sequence & Schedule

It is proposed that a four (4) phase, multi-year capital project be initiated to replace the IGS process data and control systems. The recommended sequence and schedule are provided below.

1. **Data Acquisition Systems: FOX 1/A Systems and Sequence of Events Recorders**
   FOX 1/A and Rochester SOE replacement is recommended for Phase 1 and Phase 2 of the project beginning with Unit 2 in 2003-04 and concluding with Unit 1 in 2004-05. Reasons for replacement are:
   a. FOX 1/A systems reliability is a critical concern. These systems stand the greatest risk of failure and suffer from increasing failure rates. Delay of FOX 1/A replacement will likely reduce availability of alarming, AGC control, permissive screens, and process graphics in the control room.
   b. Outage window constraints will not allow complete DCS replacement on a unit during a single outage. Replacement of both data portions of the DCS (SOE and FOX 1/A) is recommended for phases 1 and 2 to balance installation burden between project phases.
   c. FOX 1/A and SOE replacement prior to the controls will allow operations personnel to gain experience on the DCS hardware prior to being required to use the same type of hardware for unit control.
   d. The phased replacement of the DCS systems will reduce dependence on contractor labor, minimize risk to availability, and lower the overall project cost.

2. **Simulator**
   The installation of a simulator is recommended to begin in 2003-04 with completion no later than 2004-05. Completion of a simulator is required eight (8) to twelve (12) months prior to the controls in order to realize the full benefits. The benefits of a simulator are as follows:
   a. Controls can be developed and tested prior to installation of the control systems. This will minimize the post-outage start-up time.
   b. Operations personnel can be trained in advance on the new controls to ensure high availability with the new systems.
   c. Operational equipment scenarios with alternative controls solutions can be tested by Operations and Engineering.
   d. Other appropriate support personnel can be trained in advance.

3. **Controls: CCS, Turbine, BFP, and Burner Management Controls; Flame Scanners; and, Overall Systems Optimization**
   Replacement of the controls is recommended for Phase 3 and Phase 4 of the project. Unit 2 controls replacement installation is envisioned for 2005-06 with Unit 1 replacement following in 2006-07. Replacement is essential for the following reasons:
   a. The current systems are at capacity. New controls hardware will be required for the NOx reduction project.
   b. The existing systems are becoming obsolete. Unacceptable levels of reliability and availability are expected.

Deferral of the FOX 1/A replacement is possible but not recommended for reasons explained in greater length in subsequent sections of this document. The installation of a simulator and new controls systems cannot be deferred beyond the recommendations of this report, however acceleration of these phases is possible if warranted. A recommended schedule is found on page 3.

# RECOMMENDED DCS REPLACEMENT TIMELINE

| Calendar Year | * Denotes Approximate Date of Annual Major Outage<br>2000 Jul · 2001 Jan · Jul · 2002 Jan · Jul · 2003 Jan · Jul · 2004 Jan · Jul · 2005 Jan · Jul · 2006 Jan · Jul · 2007 Jan · Jul · 2008 Jan | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Budget Year | FY2000-2001 | FY2001-2002 | FY2002-2003 | FY2003-2004 | FY2004-2005 | FY2005-2006 | FY2006-2007 | FY2007-2008 |
| FOX 1/A Replacement Schedule | Technology investigation | Continue technology investigation, complete preliminary engineering, identify qualified bidder, budget, and develop preliminary specifications, issue RFP, Select Vendor. | Complete preliminary engineering, budget, and develop project specifications, issue RFP, Select Vendor. | [redacted] | [redacted] | | | 12/31/07<br>New NOx Requirements on 12/31/2007 Replacement must be completed prior to NOx deadline. |
| Simulator Replacement Schedule | | | Budget for simulator, complete preliminary engineering, budget, and develop project specifications, issue RFP, Select Vendor. | [redacted] | [redacted] | [redacted] | | |
| CCS, Turbine, BFP, and Burner Managment Systems Replacement Schedule | | Operator Training | Complete controls integration and testing on simulator and begin training. | Controls Software Development Initiated | Budget for CCS, GE, Bailey, BFP, and SER replacement systems. | [redacted] | [redacted] | |

# OVERVIEW of RECOMMENDED SCHEDULE

Year 1: Fiscal Year 2001-02

1. Complete preliminary system engineering.
2. Initiate update of DCS documentation.
3. Complete investigation and define preferred technology for DCS replacement systems.
4. Identify qualified vendors.

Year 2: Fiscal Year 2002-03

1. Develop specifications for replacement DCS and Simulator Systems.
2. Submit specifications with requests for proposals to DCS and Simulator vendors.
3. Evaluate proposals and select DCS and Simulator vendors.
4. Complete documenation of DCS systems and databases.
5. Begin development of Simulator.

Year 3: Fiscal Year 2003-04

1. Purchase and install Unit 2 DAS and SOE systems.
    a. Build and configure DAS and SOE systems.
    b. Receive, stage, and pre-test Unit 2 systems.
    c. Train DAS and SOE system users and support personnel on tested system.
    d. Remove old system and complete full installation during the four (4) week U2 outage.
2. Purchase Simulator and begin development
    a. Initiate DCS vendor development of DCS controls software and logic.
    b. Receive, stage, and test simulator hardware at Simulator vendor site.
    c. Develop simulator model.
    d. Receive controls software from DCS vendor and begin DCS integration with Simulator.

Year 4: Fiscal Year 2004-05

1. Purchase and install Unit 1 DAS and SOE systems.
    a. Build and configure DAS and SOE systems.
    b. Receive, stage, and pre-test the Unit 1 systems.
    c. Complete training for support personnel and system users on tested system.
    d. Remove old system and complete full installation during four (4) week U1 outage.
2. Simulator Development and Implementation
    a. Complete Simulator development and testing of simulated unit models.
    b. Build DCS controls displays.
    c. Complete controls integraation and check-out on Simulator
    d. Complete system FAT and SAT testing for simulator.
    e. Begin operator training.

Year 5: Fiscal Year 2005-06

1. Continue operator training on Simulator.
2. Purchase and install controls portion (CCS, TCS, BCS, and BFPT Controls) of DCS system for Unit 2.
    a. Finalize development of DCS controls interfaces and displays.
    b. Receive, stage, and pre-test the Unit 2 DCS system.
    c. Remove old system and complete DCS installation during four (4) week Unit 2 outage.
    d. Remove main control panel and replace with DCS command center on Unit 2.

Year 6: Fiscal Year 2006-07

1. Continue operator training on Simulator.
2. Purchase and install controls portion of DCS system for Unit 1.
    a. Receive, stage, and pre-test the U1 DCS system.
    b. Remove old system and complete DCS installation during four (4) week Unit 1 outage.
    c. Remove main control panel and replace with DCS command center on Unit 1.
    d. Replace station control operator and tagging desk command center.
3. Project close out and documentation.

## ESTIMATED COST for TURN-KEY SYSTEMS

The costs listed below are general estimates based on DCS vendor turn-key pricing. Under a turn-key project, the DCS vendor would provide the system hardware, software, project management, application engineering, field service, training, construction management, and installation.

| DCS Replacement Project Cost Estimate | | | | | | | |
|---|---|---|---|---|---|---|---|
| Budget Year | 2001-2002 | 2002-2003 | 2003-2004 | 2004-2005 | 2005-2006 | 2005-2006 | **TOTALS** |
| DCS Specification Development and FOX 1/A & SOE Replacement Costs | $40,000 | $500,000 | $2,600,000 | $2,600,000 | $0 | $0 | **$5,740,001** |
| Simulator Replacement Costs | | $300,000 | $1,200,000 | $200,000 | $100,000 | $0 | **$1,800,000** |
| Controls Replacement Costs | | | $800,000 | $0 | $3,200,000 | $3,200,000 | **$7,200,000** |
| Job Total | $40,000 | $800,000 | $4,600,000 | $2,800,000 | $3,300,000 | $3,200,000 | **$14,740,001** |

## RECOMMENDATION for FOX 1/A SYSTEMS

Replacement of the FOX 1/A system is recommended as the initial segment of the plant DCS upgrade project. Replacement is recommended beginning in the 2003-04 budget year with completion scheduled for 2004-05. The replacement data acquisition system (DAS) should be selected to be compatible with the controls replacement system.

The obsolete nature of the FOX 1/A and the time in service of most system components have resulted in a trend of increasing system failures and reliability problems. This trend is impacting system availability. It is not expected to improve. Additionally, the processing and monitoring capability of existing systems is near capacity. Delay of FOX 1/A replacement is an option, but not recommended.

BENEFITS
The replacement of the FOX 1/A system would bring the following benefits:

1. **System obsolescence and reliability issues solved.** Removal and replacement of the existing system with new technology systems would eliminate the availability and reliability problems currently being experienced on the unit DAS systems.

2. **Improved unit monitoring capability.** New technology systems have vastly increased monitoring capability and analysis power, and these systems require significantly less floor space that existing systems. A replacement system would offer could be expected to supply more data, faster, and more reliably than the existing systems with significant expansion capability.

3. **Reduced long-term spare parts and support training costs.** Replacement systems would be selected that would be compatible with the controls replacement DCS systems and in large part use common spares. The current collection of varied systems would be replaced with an integrated system from a single vendor. Elimination of the need to train all systems personnel on a variety of systems would reduce training costs.

4. **Improved data to the plant information system.** The replacement DAS system would provide a standardized, higher capacity data link to the plant information system.

5. **Pre-training and experience in the use of the replacement DCS system technology.** The replacement FOX 1/A systems would use the same type of equipment as the controls replacement systems though implemented for data acquisition only. While this does not replace simulator/controls training, it provides operators with experience on the DCS replacement system hardware in advance of the DCS installation.

Every effort is currently being made to extend the service life of the FOX 1/A systems to the absolute end of OEM or third party support. Current trends, however, indicate that within three (3) to five (5) years such a course will likely result in a serious and extended system failure and a corresponding breach in the availability of measured process data and dependent analytical and predictive data. Accordingly, a project to replace the FOX 1/A should begin by 2001-02.

## RECOMMENDATION for SIMULATOR

Purchase of a modern high-fidelity simulator is recommended as part of a plant DCS upgrade. Currently many fossil utilities are investing in simulators to be competitive in a deregulated energy market. There are two main reasons: to improve plant operation, and to aid in changing to a new DCS. Advances in simulator technology have made it possible to have an exact model of a power plant's processes and equipment. This allows the simulator model to be controlled by a copy of the plant DCS software.

BENEFITS

The benefits of a Simulator are as follows :

1. **DCS control testing tool.** DCS controls can be configured, tested, debugged, and tuned on the simulator before the unit outage to change out the control system begins. This reduces the amount of work that needs to be done during the outage and can reduce the overall outage time. Fewer problems bringing the unit back online would be expected. The decrease in outage time could pay for the cost of the simulator.

2. **Operator training tool.** The simulator would allow operators to train on the new DCS before it is installed. The simulator representation of the plant and controls would be very realistic, and it would be an ongoing tool to keep operators "current" on scenarios that are not common during normal operation, helping to maintain high availability.

3. **Unit performance testing tool.** Using the simulator as a testing tool has allowed some plants to ramp faster, operate at lower/higher loads, and avoid trips. "What if" scenarios could be run on the simulator to investigate the results of different operating conditions, or equipment changes.

4. **I&C technician training tool.** The simulator would be a technician training environment for the DCS controls as well as the DCS hardware.

The simulator could be purchased as a turnkey system or as a kit. The "kit" option is the recommended approach. A kit system would involve IPSC personnel assisting the vendor in configuring the controls and plant model, as well as validation of the simulator at various load conditions. Likely, operators, I&C technicians, and engineers would be need to be assigned to do this work. The two options are described below:

1. **Kit Option.** A kit would cost about $1,200,000 and take about 2 years. It would cost about 65 % of a turnkey system. A kit offers the benefit that IPSC personnel would gain an intimate knowledge of the internal details of the simulator design and the plant controls. This knowledge is directly transferable to the control system software and hardware.

2. **Turn-Key system.** The estimated cost of a turnkey system is $1,800,000 and it would take 18 months to complete. The main advantage is a shorter project completion time, about 6 months shorter. Also, fewer IPSC personnel would be required to complete the project.

## CONTROL SYSTEM REPLACEMENT

Replacement of the present control systems must be completed prior to the NOx modifications which will be required by December 31, 2007. This is based on the need for additional control hardware for emissions reduction and obsolescence of the current equipment. The systems listed below are the main plant controls and would function more effectively as a single system. Installation of a unified control system will result in improved control capability. It will also reduce the amount of required hardware for the operator interface, result in decreased maintenance (single system with less hardware to maintain), simplify troubleshooting, streamline training, and a result in a reduction in warehouse inventory.

The following systems are recommended for replacement as part of the DCS upgrade:

1. Foxboro Videospec/Microspec combustion control system (CCS)

2. Bailey Net-90 burner controls system (BCS).

3. General Electric Mark IIA turbine controls (EHC), turbine generator supervisory instruments (TGSI), turbine automatic controls (TAC), and MDT-20 controls for boiler feed pump turbines.

4. Rochester AN-4100 and ISM-1 annunciator and sequence of events recorder (SER).

The present combustion controls (Foxboro CCS) have had several modifications over the last 14 years which have used spare hardware and software capacity. This will prevent any further significant changes to the combustion controls in the future without a major upgrade.

The General Electric (GE) systems have experienced multiple problems over the years. EHC failures have caused unit trips and TAC failures have occurred during critical times including unit startups. The TGSI systems have had problems with the disk/tape drives subsystem which has required an interim replacement. Additionally, the TGSI operating system is costly as well as cumbersome to modify. The boiler feed pump turbine controls have had problems with calibration drift which cause difficultly with the calibration lineup during outages. A further concern with the GE systems is vendor support. The number of GE personnel remaining who can support these systems is limited.

The Bailey Net-90 systems are becoming obsolete and are experiencing problems with the main processors (logic master modules). These modules are very sensitive to power spikes that cause the memory to be corrupted and require a reload of the operating parameters after system power is cycled.

A new, single control system could tie all of these systems together and provide redundancy, seamless intercommunication, ease of operation and maintenance, and increase the reliability of the unit operation. The enhanced control system will modernize the unit operations providing a new control console for the operators.

<u>Recommendation for Foxboro Videospec/Microspec Controls:</u>
Replacement of the Foxboro systems is recommended as part of the total controls replacement. As indicated above, these systems have no expansion capability. Also, long term vendor support is a

concern. We expect to be able to support this system through 2007; however, Foxboro has transferred support of this equipment to an outside company, Process Control Systems (PCS). While PCS has indicated a potential 10 year support for this system, that support is based on availability of spare parts. Additionally, some of the processor and i/o boards for these systems have custom modifications unique to IGS. This further complicates the support forecast. Parts availability has been a problem for the Foxboro FOX 1/A systems which is the same generation as the Videospec/Microspec. This may indicate that similar, future problem for the Videospec/Microspec. It is certain that the replacement of the Foxboro controls will be necessary well ahead of any regulatory deadlines that require controls modifications or enhancements.

Recommendation for Bailey Net-90 Burner Controls:
Replacement of the Bailey Net-90 Burner Controls is recommended as part of the final segment of the plant DCS upgrade project. This system controls the operation of the pulverizers through control stations on the main control panel. We can eliminate a large amount of hardware and software by combining this system with the main plant digital control system (DCS).

There have been numerous problems with this system over the years. A problem with the grounding in this system caused problems with the flame scanners which resulted in pulverizer trips on loss of flame indication. The Logic Master Modules (LMM) have extended startups due to a loss of program. Power supply failures have caused unit trips and required a modification to a redundant power supply system. It is expected that adequate support for the Bailey hardware will be available until the recommended replacement window. However, the current software used to interface with the Bailey system is obsolete. It is DOS/Windows 3.1 based and will require an upgrade in the near future.

Recommendation for General Electric EHC, TGSI, TAC, and BFPT MDT-20 Systems:
We recommend that the General Electric systems be replaced as part of the final segment of the plant DCS upgrade project. Combining the key control systems into a single system resolves numerous problems associated with the present system.

These systems are expected to be maintainable until completion of the DCS upgrade. But, there is some risk of further intermittent failure due to the remaining, unresolvable problems. The turbine controls have had problems with mercury wetted relays, test circuits that fail, and circuit board component aging causing drifting of settings. The information portion of the system, TGSI, has had problems with the data collection and historical portion of the system. The TGSI to FOX 1/A data link is antiquated causing the update cycle to the information computer to be in excess of four (4) minutes. Discussions with GE to improve upon this communications link have not resolved this situation due to the GE costs required to make changes to our old system (> $100K/unit). The TAC system has had problems since startup. These problems have never been resolved and GE only made ten of these systems due to the problems they encountered. The BFPT controls are an old vintage that are prone to drifting due to the discrete components on the circuit boards. All these systems have problems which would be resolved by replacing them as part of a main plant total DCS replacement.

As indicated earlier, a further concern with the GE systems is vendor support. The number of GE personnel remaining who can support these systems is limited. Also, the turn-around time on repairs and the quality of the actual repairs have been unacceptable in several instances.

Recommendation for Sequence of Events Recorder (SOE):

We recommend that the Rochester Sequence of Events Recorder be included for replacement as part of the plant DCS upgrade project and installation scheduled concurrent with the FOX 1/A system replacement. Concurrent replacement will balance DCS replacement scheduling and demands during outage periods between the four (4) DCS project phases. SOE replacement will bring all the necessary information into a single DCS platform.

This system was upgraded approximately eight years ago to the current ISM-1 system for audible annunciation and sequence of events. Problems have continually plagued the system with lock-up of the system for no apparent reason. Several attempts by Rochester to repair this problem have not been resolved. This is a critical system when troubleshooting equipment or unit trips.

BENEFITS

The benefits of controls replacement with a coordinated DCS system are as follows:

1. **Improved Control Capability:** These newer systems have finer control capability which enable better control of the boiler, turbine and feed pumps. They have systems available to evaluate tuning parameters, for all control loops, to enhance total system operation. These systems can also be used as a troubleshooting tool to evaluate problems and help with determining resolutions.

2. **Load Ramp Improvement:** The newer controls have a better ability to control key parameters during a load change which allows a quicker load increase or decrease. This may be important in the future with a de-regulated market.

3. **Performance Enhancement:** An improvement in efficiency has been demonstrated in the new control systems. Even though we already have a high heat rate, improved performance will be seen with tighter control of pressure and temperature with the newer boiler controls.

4. **Reduced Hardware:** The newer DCS systems allow a reduction in interface equipment because of the direct connection of instrumentation through the DCS system. This means that recorders, switches, lights, control stations, and indicators will be wired directly to the DCS . This eliminates the equipment and the wiring.

5. **Training Standardization:** Having all the control in a single system minimizes the training requirements. Costs will be reduced and overall training needs decreased.

6. **Warehouse Inventory Reduction:** Total control parts inventory can be reduced significantly by combining systems into a single manufacturer for key control systems.

7. **Central Information Gathering:** All information from each system would come to the new DCS system. No special data interfaces would be required as they are now, ie. TAC, TGSI and SER data links. Current and historical data would be available for plant personnel to review and evaluate from a single source.

## POTENTIAL ECONOMIC BENEFITS

DCS vendors advocate that a new DCS would reduce generating costs and improve competitiveness in the following areas: improved megawatt ramp rate, O2 improvements, sootblowing reduction, improved availability, reduced maintenance costs, reduced inventory costs, reduced NOx emissions, improved productivity, and lower training costs. Of these, megawatt ramp rate, and improved availability are thought have the largest potential dollar value:

1. **Improved ramp rate:** Many western utilities are upgrading control systems with increased unit ramp rate being a primary objective. An improved ramp rate allows them to be more responsive to dispatch demands and competitively capture "spot market" power sales. IPSC engineering personnel do not have the necessary marketing information needed to estimate the potential benefit of an increased ramp rate.

2. **Improved availability:** A new DCS could be expected to improve availability due to fewer future trips, fewer runbacks, and shorter startup time after trips and outages. The potential benefit could be significant considering that trips and reduced availability are expected to increase as the existing control equipment ages. No estimates for the value of potential benefits have been made.

**Maintenance Costs**: Maintenance costs on a new system would likely not be less than what IPSC is experiencing now. Past costs have averaged $69,000 over the last 4 years to maintain the Fox 1/A, CCS, RIS, Bailey Net 90, and GE systems. This number was identified from purchase order information ( purchases, repairs, rebuilds) assigned to control system equipment codes. Likely, there are some costs that were assigned to the plant equipment numbers rather than the control system equipment numbers and are not reflected in the above total. The table in "Attachment A", Summary of Current System Maintenance Costs, shows that the Fox 1/A accounts for most of the yearly cost.

Future costs would depend on the level of support that IPSC desired from the DCS vendor, but they could be estimated to be from $100,000 to $200,000 per year. This is based on the maintenance agreements that the Navajo and Bonanza plants currently have.

**Reduced Spares in the Warehouse:** The total number of spare parts required to support a new DCS system would be greatly reduced from the current number now on hand. The DCS would combine systems from several vendors into a system from a single vendor. The cost savings due to a reduced need to stock and warehouse parts has not been estimated. Currently, the warehouse has over $1.5 million dollars in spare control parts ( values as assigned in the TIMS system):

| | |
|---|---|
| Foxboro, 1/A and CCS | $629,200 |
| RIS | 140,000 |
| Bailey | 111,624 |
| GE | ~200,000 |
| Modicon | ~500,000 |
| | ~$1,580,000 |

**Reduced NOx Emissions.** One DCS vendor asserts a potential reduction in NOx emissions of up to 12 % with a new control system. The vendor estimates this would relate to a 4 % reduction in the capital cost of SCR NOx controls or over $2 million dollars. IPSC has not investigated the likelihood that a new control system at our plant would reduce NOx emissions.

SUMMARY of DCS UPGRADE SITE VISITS

## Summary of Plant Visits to Bonanza and Navajo Power Plants
## DCS Control Upgrades

**Reason for upgrades:** Navajo and Bonanza upgraded to a new DCS because of obsolescence of old control hardware and difficulty in maintaining the equipment. Also, upgrades were done in conjunction with plant changes: new scrubbers at Navajo, and turbine and pulverizer upgrades at Bonanza.

**Systems upgraded:** Both plants have upgraded older controls to a Foxboro I/A DCS system. Bonanza did the project in four steps over 2 years: the DAS (information computer systems), scrubber controls, power block relay logic and BFP controls, and finally the turbine, burner management, and DCS controls. At Navajo, they also did their DAS systems first, then all the controls for each of three units were done, with one unit completed each year during an 8 week outage.

**Turbine controls**: Both plants replaced their dedicated turbine controls with the controls done in the Foxboro DCS. Both report this has worked well.

**Burner Management:** Both plants now do burner controls in the new DCS, replacing older dedicated systems.

**SER**: (Sequence of events recorder, or SOE) Both plants have their SER functions done in the new DCS.

**Sootblowing:** Bonanza uses sootblowing done in the new DCS. Navajo has integrated the DCS to an older PLC sootblowing system.

**PLCs vs DCS controls:** Both plants use the new DCS for power block logic (motor control of fans, pumps, etc) rather than PLCs. They also both have their scrubbers run by the DCS rather than PLCs. PLCs are still used in many areas of the plant.

**Control Board Replacement:** Both plants removed their control (BTG) boards and replaced them with an arrangement of CRTs. The big disadvantage with the computer screens noted by operators is that they couldn't see as much at once. Also, it can be slower using the screens to take action. However, comments by unit operators indicated that they liked the new controls and layout better than the old controls. Direct-wired trip buttons were available for critical equipment. Both plants had touch screens but did not recommend them or use them much, except the touch screen helps to locate the cursor on the screen quickly. Navajo used trackballs and Bonanza used mice for screen pointing.

Navajo used mostly standard graphics provided by Foxboro. At Bonanza operators built custom displays with as much information as possible on one screen. They tried to design the displays so an operator could get to where he needed to go with one mouse click. Both sites seemed pleased with what they had.

**New Control Operation:** The new controls require less operator intervention and are not operated in manual as much. The unit operators operate scrubbers from the main control room now at each plant. Normally, this requires as much time as running the units. At Navajo, the new controls are very stable, and handle runbacks very well. Ramp rate was 5 mw/min before and now 75 mw/min is possible. N0x emissions were unchanged.

**Simulator:** Navajo wanted a simulator at the time the project was beginning, but could not get approval from all participants in the plant. They now have that approval and are proceeding to procure one. Bonanza purchased a simulator from Esscor as a kit. Much of the modeling was done in-house. It was very successful for controls checkout and initial tuning.

**Support of System:** Both plants maintain and support their systems with a limited group of dedicated people. Navajo has a system administrator (a former unit operator), and I&C techs assigned to the new system. Bonanza has 2 engineers and 2 I&C techs assigned to their system. Additionally, an operator is the graphics expert. Technicians were pleased with having fewer different systems to learn since several systems have been consolidated into the DCS. Also, there are fewer different parts to warehouse. Each plant indicated a high level of expertise (training and hands-on experience) is needed to support the DCS. Also, both plants have maintenance agreements with Foxboro ranging from $140,000 to $290,000 per year.

**Project Management:** Navajo's specification and contract was done by the corporate office in Phoenix. Personnel at Page oversaw the installation and startup. Bonanza did their own specification and contract with outside help. Both sites contracted with Forney Systems to move their burner management systems to Foxboro I/A, and both used contract people during the installation for wiring.

**Comments on Foxboro:** Both sites reported Foxboro has very good hardware and they were pleased with the system and startup. Both said be wary of using Foxboro Cluster I/O. It is cheaper but will not function well in all environments. Both use UNIX for an operating system, and do no recommend using NT.

Attachment # 1 - Summary of Current System Maintenance Costs

## Attachment 1

### Summary of Maintenance Costs for Control Systems
(costs on purchase orders, repairs, rebuilds)

| [redacted] | | | | | | | Average/ year (4 yrs) |
|---|---|---|---|---|---|---|---|
| [redacted] | | | | | | | **41715** |
| | 1 | 1INF--0 | 83079 | 53710 | 41540 | 26855 | 34197 |
| | 2 | 2INF--0 | 22620 | 7450 | 11310 | 3725 | 7518 |
| [redacted] | | | | | | | **14763** |
| | 1 | 1COA--0 | 21085 | 17134 | 10543 | 8567 | 9555 |
| | 2 | 2COA--0 | 11151 | 9680 | 5576 | 4840 | 5208 |
| [redacted] | | | | | | | **3452** |
| | 1 | 1INF--B | 1116 | 8242 | 558 | 4121 | 2340 |
| | 2 | 2INF--B | 658 | 3792 | 329 | 1896 | 1113 |
| [redacted] | | | | | | | **1447** |
| | 1 | 1SGH--0 | 988 | 330 | 494 | 165 | 330 |
| | 2 | 2SGH--0 | 2974 | 1494 | 1487 | 747 | 1117 |
| [redacted] | | | | | | | **7886** |
| | 1 | 1TGF--0 | 11278 | 2903 | 5639 | 1452 | 3545 |
| | 2 | 2TGF--0 | 14416 | 2945 | 7208 | 1473 | 4340 |
| **TOTAL** | | | [redacted] | | | | **69261** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| [redacted] | | | | | | | **4565** |
| small part of | 1 | 1COF--0 | 3108 | 4987 | 1554 | 2494 | 2024 |
| modicons | 2 | 2COF--0 | 1017 | 1358 | 509 | 679 | 594 |
| | 9 | 9COF--0 | 2787 | 5002 | 1394 | 2501 | 1947 |
| [redacted] | | | | | | | **126750** |

** Most of the Modicon costs are charged to plant equipment numbers other than COF--0. Costs are actually much higher. This happens to a smaller degree for Fox, CCS, Bailey, GE, & RIS , so their costs are higher.

Attachment # 2 - Notes on Bonanza Plant Visit

# Fact Finding Tour
# DCS, DAS, & Simulator Replacement Project
# Bonanza Power Station

**Visit to Deseret Generation's Bonanza Power Plant: 14-Sep-00 Notes: J. Burr**

**Reason for upgrade:** Deseret upgraded because of obsolescence of control hardware. They had experieinced support problems with their Westinghouse system. They also had a goal to standardize plant controls into 2 systems. Foxboro and Allen Bradley. They used a step approach by doing their data acquisition system first, then minor systems, then the major ones together with a turbine upgrade and mill upgrade. Plant capacity is now 490 gross, up 50 mw from before.

**Systems looked at:** Honeywell, good software; Foxboro, good hardware; Westinghouse, was not responsive on info or bid (Ovation is new system)

**Systems upgraded:** The stepwise approach did have some problems, with getting data between systems. In 1998 they started and did the DAS system with 1200 points and it took 1 year. The next steps: Scrubber controls; relay logic, BFPs; BMS, DCS, turbine, in spring of 2000. Next, they will replace the electrical control board.

**Turbine controls:** These are now done in Foxboro and they work well. They do use a triconics analog card (has been a minor problem) but now a digital version is out and is better. They have had very few problems with the new controls done by Foxboro. Tim Cosca is the Fox turbine controls guy.

**SER**: (Sequence of events recorder, SOE) Replaced their RIS with Foxboro, points went from 1300 to 600 or less. ~2/3 point reduction. Now the Seq. Of Events is just a database not prints. Points come to a CP processor, but timing is an issue because Cps are not synced. Should be synced to a satellite or standard time. Print to 1/10 th of a second, but the software records to the milli second level, and this can be dumped out.

**Sootblowing:** They replaced their old system with Foxboro sootblowing done from a CRT.

**Vibration:** They replaced their Bentley-Nevada system with one from SKF. Bentley was double the money?

**PLCs vs DCS controls:** Previously power block logic was done with relays, not PLCs. The replacement choice was between the Fox DCS and Allen Bradley PLCs. The Fox DCS was chosen and this has worked well. Foxboro gateways (integrator 30s) to link to the PLCs are expensive and limited on points. By bringing the logic to the Fox controllers (CPs) they could consolidate better than using PLCs and have redundancy built in. Allen Bradley is cheaper per I/O point but the integration would have cost more, even with non-redundant gateways. From other areas in the plant they have 20 PLCs coming in on 8 Foxboro integrator 30s.

**Control Board Replacement:** They replaced the control board with a bank of CRTs. One big drawback noted by operators was that they couldn't see as much at once with the screens. Also, they felt it can be slow to go to the desired computer screen when trying to take action. Removing the board and going to CRTs is a paradigm shift that takes getting used to, but operators indicated for the most part it has been good. The new controls require less intervention and are not operated in manual as much. Also Deseret had operators design their graphic screens and most actions are only one page away. In the control room they had 7 workstation screens for Foxboro controls, and one big, large monitor, and they had a sootblowing system screen. They operate their scrubber from the main control room now.

**New Control Operation:** They have just installed their system this last spring. The plant turbine was also upgraded so many comparisons of how the old controls relate to the new are not well defined. Also, there is still tuning to be done, but they chose to run the plant this summer during the high demand for electricity and tune later. Operators and engineers said they were happy with the new controls.

**Historian:** They use the Foxboro Aim-Star historian and have 1 ½ months of data available on an optical disk. They turn the disk over for the other 1 ½ months. A hard disk would be better.

**Simulator:** Much of the modeling was done in-house with help from Esscor, by Larry Jorgensen a shift supervisor with a CS degree. The big plus of the simulator was with controls checkout and controls tuning. It was very successful. Hugh Scigliano from Foxboro used it to check out and tune the controls before loading the controls on the real system.

**Support of System**: They maintain and support the system with two engineers and two I&C techs assigned to the new system. They indicated other techs will get a chance later to work on the system. A unit operator was the graphics person and still supports that effort. Techs like only having to learn two systems now, Foxboro and AB. They felt that a smaller group of trained and dedicated people was necessary to manage the system. They have a maintenance agreement with Foxboro for ~$140,000 per year. This seems expensive.

**Project Management:** The spec was done with help of Burns and McDonnel. During the installation they used DTC (a contractor) to do wiring. They advised us to use a digital camera on the bid spec, it helps a lot. It is important to have a database including every termination. They contracted with Forney Systems to move their burner management system and baghouse logic to Foxboro I/A. In their spec, they should have had language to handle change orders and pricing better. With Foxboro there isn't really a fixed price, but one could expect to pay 30% to 40% of the list price.

**Comments of Foxboro:** Very good hardware. They are pleased with the system and startup. They recommend designing own graphics rather than using standard Foxboro graphics. They do not recommend getting the Foxboro Cluster I/O. For the DCS operating system they use UNIX not Windows NT. They have heard of problems with NT.

**Personnel:** Robert Strolle- e. engineer 435-781-5733
Mike White- e. engineer
Tom Howells- operator and graphics guy
Kreig Parker? I&C tech
Thomas Wilhem- planner and results tech ( e guide)

**Visit to Deseret Generation Bonanza Power Plant: 14-Sep-00 Notes: K. Nielson**
Attendees: James Burr, Ken Nielson, Alan Williams, & Bill Morgan

Bonanza replaced control systems by standardizing on Foxboro IA for CCS, Burner,Turbine controls and DAS; and Allen Bradley for PLCs. Previously had an array of systems including Westinghouse, Forney, Fisher, Foxboro and other. Controls replacement allow elimination of control board and reduced required operator staffing. The new systems increased information and control capabilities. 3 year phased project beginning with DAS. Simulator was installed and recommended. Recommended having simulator installed 1 year prior to controls. Bonanza pleased w/ new Foxboro IA system and Foxboro support. Further detail is provided below.

**Bonanza Site Visit Details**
The following list of questions was compiled to review during the site visit:

1. Why were the old systems replaced?
2. Was the replacement system installed in a single phase or multi-phase project?
3. How was the replacement project done?
4. Was an independent Data Acquisition System (DAS) installed?

5. Was the DAS system done at the same time as the Coordinated Control System (CCS)?
6. Did they do the controls or take old controls and transfer them?
7. How long did it take to do the new controls?
8. Who configured the process graphics and operator interfaces?
9. Was a simulator installed?
10. Where in the project chronology was it installed?
11. How was the simulator done?
12. How were operators and system users trained?
13. With operators trained, how much continuing training is done?
14. Is the simulator used to test 'what if' scenarios for the CCS?
15. Were control rooms modified with the new CCS? If so, how?
16. How is support staffing structured for the new DCS, DAS, and Simulator systems?
17. How were support personnel trained?
18. Which/What replacement system(s) were selected? Why?
19. How successful and accepted has the replacement system been?
20. How was replacement project support from the system vendor?
21. How has post installation support been?
22. Does the vendor offer continuing modernization/upgrade support plans?
23. Are these used?
24. What are the details of such this plan?
25. What would be done differently?

Discussions on the replacement project and recorded notes are organized below according to the pre-compiled question list shown above.

1. What were the previous control systems?
   a. Previous to the current systems, Bonanza had Westinghouse controls, Forney burner controls, and an array of control systems and PLCs.

2. Why were the old systems replaced?
   a. Replaced old systems due to support problems from Westinghouse and due to system obsolescence.
   b. In some cases, they had been notified that support for particular components would be dropped within 1 to 2 years.

3. Was the replacement system installed in a single phase or multi-phase project?
   a. New systems part of a multi-year project that began in 1998. Started with the DAS first, then as much of the controls on-line as possible, then the CCS, Turbine, and Burner control systems.
   b. In 1998 the DAS system was installed. Approximately 1200 points in the DAS.
   c. Replaced the scrubber controls about 6 months later followed by the relay logic. Much of this was done on-line.
   d. Replaced the CCS in the spring of 2000. An outage was required for this segment of the replacement project. It was also done concurrently with the replacement of the turbine rotor and some of their pulverizers.
   e. There is a lower outright cost to do all controls at the same time due to the amount of data links required to old systems. But, the phased approach allowed operators time on the IA DAS system while allowing them to use the old familiar controls.

4. How was the replacement project done?
   a. Contracted with AE was done to prepare as specification for the procurement process. However, a modified version prepared by Bonanza technical staff that was more useable and is the basis for the project documents.

b. Specified that replacement systems would be standardized. Though installed in phases, proposals were for all segments of the replacement systems.
c. Project management done by engineering at Bonanza.
d. Much of the system configuration done by DG&T personnel.
e. Simulator development done by in-house support at Bonanza. See more information below.
f. Contractors used in I/O replacement.
g. Controls and system configuration done by Bonanza staff, Foxboro, and Foxboro subcontractors.
h. Graphics built by operations personnel.

5. Was an independent Data Acquisition System (DAS) installed?
   a. The DCS and DAS system are integrated and considered part of the same system. They are separate components of the IA system at Bonanza.
   b. Currently, use I/A for DAS. Use AimStar historian by Foxboro. Started with FoxHistory, but found that system to be unreliable. That was replaced by the Aimstar system.
   c. Likely to go to an off-platform systems in the future to provide desktop access to data.
   d. PC/Desktop access is available to a limited amount of on-site users. PC/Desktop access is available through connection to an AW (applications workstation) to authorized users only.

6. Was the DAS system done at the same time as the Coordinated Control System (CCS)?
   a. No. Though considered now to be different components of the same system, the DAS segment of the system was installed about 2 years prior to the CCS systems.

7. Did they do the controls or take old controls and transfer them?
   a. Rebuilt from the ground up by Foxboro.
   b. Controls were test and pre-tuned on the simulator.
   c. Old terminal blocks were used where possible, but most I/O terminal blocks from previous systems were replaced.

8. How long did it take to do the new controls?
   a. Done by Foxboro (thought to have taken about 1 year.).
   b. Tuning included dumping the controls to the simulator. Then, made changes on the DCS according to what they had done and tested on the simulator. They did not dump the controls back to the DCS.
   c. The tuning was sufficient to allow successful start-up and operation to meet production demands. However, additional tuning will be completed on the on-line system during their fall outage.

9. Who configured the process graphics and operator interfaces?
   a. Operators built and largely support modifications to the DAS graphics. This was very successful and recommended. Minimally, there should be operator involvement in the graphics display creation.
   b. Some graphics simulate old manual controls with added trends and color status indicators.
   c. They do not like the touch screens. While sometimes convenient, they are costly to maintain and reliability is not as high as they would like.
   d. One operator is assigned and acts as the controller up implementing changes and enhancements.
   e. Estimated that 1.5 to 2 man-years were required to build the graphics.

10. Was a simulator installed?
    a. Yes, a Simulator by Esscor.

11. Where in the project chronology was it installed?
    a. Implemented between the DAS and CCS replacement systems.

12. How was the simulator done?
   a. Esscor simulator. The basic simulator 'kit' was received from Esscor and the simulator system was built by Bonanza personnel.
   b. Received simulator for operator training just prior the spring 2000 outage. This was insufficient to allow adequate training time for operations personnel on controls.
   c. Simulator was used for pre-startup tuning. The pre-tuning effort was very successful.

13. How were operators and system users trained?
   a. Operators had one (1) to two (2) years experience with the DAS part of the IA system and the scrubber controls.
   b. They recommended that the DAS be installed a year or two in advance to allow familiarization w/ Foxboro IA before use for start-up and unit control.
   c. Only a month or two of simulator training was available for simulator training prior to restarting the unit.
   d. There were no trips due to operator error. Had one trip due to the failure of an IA system CP (control processor) failure.

14. With operators trained, how much continuing training is done?
   a. So far, work is continuing on the simulator by systems personnel as time permits.
   b. Little additional training has been done. However, operations an engineering personnel would like to see much greater user of the simulator for training.

15. Is the simulator used to test 'what if' scenarios for the CCS?
   a. Not currently, but intend to do so.

16. Were control rooms modified with the new CCS? If so, how?
   a. Yes, manual control boards were replaced with CRTs. Pre-installation of the DAS allowed familiarization w/CRT before manual systems are removed. Plus new controls are good enough to largely eliminate the need for manual interaction for most situations.
   b. Replaced the manual control panels in three (3) phases from 1998-2000. Phased out the control panels. Replaced with a quantity of twelve (12) 21" CRTs and one (1) 46" CRT. The new CRTs are arranged in blocks of four (4) CRTs. Each block of CRTs is separated from the next by a console with hard-wired trip/start buttons and small video screens showing some site locations. The large CRT is ceiling suspended and used for primary trends.
   c. The new CCS eliminated the need to control from the scrubber control room and put those controls in the main control room. However, an AP (application processor) has been located in the scrubber control room to allow control from that location in case there is a communications failure to the main control room.
   d. With the elimination of the control panel, the Rochester sequence of event recorder (SER) and annunciator light boxes annunciation system was eliminated. All annunciation is done from the IA system.
   e. Initially, there was considerable apprehension among operations personnel about this modification. Operations personnel indicated that once they were familiar with the new systems, they have come to prefer them.
   f. With a manual control board, multiple control switches could be activated somewhat simultaneously. With CRTs, good organization and management of control screens has been required to duplicate that capability. However, with the CRT controls, much more operating information is available. Again, display/screen organization and management is critical.
   g. DG&T operations and technical staff were unanimous in recommending that custom screens be developed in-house rather than use the standard Foxboro built screens.

17. How is support and support staffing structured for the new DCS, DAS, and Simulator systems?
    a. Have a support agreement with the TAC (Technical Assistance Center) at Foxboro. Also the utilize the FoxWatch capability that allows a secured remote login access (call back security) to authorized Foxboro support personnel. The contract cost is currently about $140,000/year. Bonanza technical staff seemed very please with this agreement and the support and results that it has yielded. Comments included that Foxboro had provided good response via this program. Without the contract, they found their support calls to be addressed on a lesser priority.
    b. Staffing includes:
        i. Two (2) systems engineers
        ii. Two (2) Dedicated I&C techs for support, backups, etc...
    c. All techs are trained to use and support the system. The ideal plan is to rotate all through the system eventually. However, they largely allow personnel to focus on areas where interests and expertise best serve the company. This seems to have fostered more ownership in care for the job and systems.
    d. Controls changes are initiated by any of the primary four (4) support or engineering personnel. Then prior to implementation on the live side, a review by at least one (1) of the other primary personnel is required.
    e. Technicians are on call on weekends.
    f. With the standardization of equipment, a great deal of the problems with rotation and getting people up to speed on equipment has been eliminated.

18. How were support personnel trained?
    a. Primary systems personnel pre-trained for system installation support.
    b. Other I&C support personnel and system users trained via on-site training class.

19. Which/What replacement system(s) were selected? Why?
    a. Bonanza standardized on Foxboro for controls and Allen Bradley for PLCs. Have found Foxboro easy to use and support.
    b. They use Foxboro for turbine controls and used Foxboro to replace the Forney burner control system, but Forney did the engineering on that portion of the system.
    c. I/O terminal blocks for the Foxboro systems were found to be superior to competitors due to size. Competitors were cited for having large terminal block while the Foxboro system use compact TB sections.
    d. Used MK Engineering system for CEM.
    e. Deseret has employed the automatic soot blowing system from Foxboro.
    f. Though Westinghouse probably had the best opportunity for winning the replacement system, they did not get the bid because they were unresponsive to the bid process, worst prepared in their proposal, and not competitive in cost.
    g. NT v. Unix: Bonanza went with Unix. Found it to be more solid to upgrade and easier to use with the application. Foxboro had had some problems with their NT versions. Bonanza has had one controls related trip. This was due to the failure of a Foxboro Control Processor (CP).

20. Were any PLCs replaced with DCS systems or DCS with PLCs?
    a. Did not use Foxboro to replace any PLCs. Did use Foxboro to replace some relay logic that should have been put on a PLC.
    b. More notes from DG&T on PLC vs. DCS control.
        i. If control can be done on a PLC and the data is not needed on the DCS, then that is cheapest and most efficient (from the system loading perspective) method to follow.
        ii. If the data is needed on the DCS then a gateway will be needed between the DCS system and PLC. There is a data capacity limit on gateways. The cost of PLC to gateway to

DCS configuration is about equal with the DCS to DCS control module. As such elimination of the PLC and control directly with the DCS control module is a viable option.

iii. Control by the DCS with a pass through to the PLC to the process is not recommended. That configuration introduces an additional 2 points of failure plus the loading/system speed impact of the gateway.

21. How successful and accepted has the replacement system been?
    a. System has been reliable. Only one trip attributable to controls. This was due to the failure of a CP hardware module and not a failure due to controls malfunction.

22. How was replacement project support from the system vendor?
    a. Excellent.

23. How has post installation support been?
    a. Excellent.
    b. Support contract and Foxwatch support has been very responsive and is recommended.

24. Does the vendor offer continuing modernization/upgrade support plans? If so, are these used?
    a. A support contract is in place with Foxboro.
    b. Contract does not include gradual modernization of new systems.
    c. Possible option for such available from Foxboro.

25. What are the details of such this plan?
    a. No information at this time.

26. What recommendations for a new project of this type?
    a. Ensure the at least 10-15% spare i/o capacity is built purchased with the new system. Recommended at least on spare slot per i/o TB pack.
    b. Write in pre-agreed methods and costs for escalation of support and installation assistance should such escalation be required.
    c. On change orders or needs for additional material, write in pricing restrictions or guarantees for the purchase of additional or future equipment. 30-40% off of list is not an unusual discount.
    d. Ensure that the vendor will supply functional, logic and detailed schematic layout drawings of the new systems and controls. Foxboro provided basic logic drawings. But AE worked with Foxboro on some controls and provided much more useable and workable detailed schematics and functional diagrams.
    e. Ensure that software upgrades during the project implementation time are included and automatic during the project implementation. This will prevent having to purchase software upgrades for previously installed systems when implementing the later phases of the project.
    f. Also, a means for routine upgrades may be built into maintenance support agreements.
    g. Used a database similar to our Fox I/A database to build and pre-configure the point databases for the new system. This was especially useful to contractors doing the wiring changes from the Westinghouse or other terminal blocks to the Foxboro TBs.
    h. Install simulator earlier that happened with their schedule.

SUMMARY

The visit to the Bonanza power station was very informative. It provided an opportunity to see the results of a controls and data acquisition system replacement project. The Bonanza DCS/DAS replacement project was pursued in a phased approach. It included the replacement of the I/O capability of the old systems and the installation of a simulator for training and pre-startup tuning.

Phase 1 installed the DAS system. Phase 2 brought the installation of DCS capability for areas that would allow on-line installation. Phase 3 installed the primary CCS, turbine, and burner control systems. That phase required a unit outage and was planned to coincide with a major unit outage in which the turbine rotor and some unit pulverizers were replaced.

The project was initiated due to obsolescence and lack of capacity in the previous systems. Foxboro was selected and the replacement for DCS systems. Allen Bradley was selected as the replacement for PLC systems. Previous systems included: Westinghouse, Forney, Fisher, Foxboro and others.

The DCS replacement project allowed replacement manual switch control boards. Control room monitoring capability included primarily CRT based operator interface. Monitoring of processes from remote or back-end control rooms was relocated to the main unit control room. This resulted in a reduced requirement for operator staffing. Operations personnel indicated that the use of CRTs for control and elimination of the manual control boards was a significant change, but was successful and now largely preferred. Old control boards allowed the actuation of multiple switches somewhat simultaneously while CRT commands could only be done one operation at a time from a single screen. The use and availability of multiple CRTs largely compensated for that advantage. And, as display design and CRT usage patterns improved with experience, operations staff indicated that they expected the CRT system to be fully superior to the manual control panels. They further indicated that the added responsibility of monitoring back-end and outer area operation from the main control room had not impeded their ability or quality of control. They attributed this to the improved control capabilities of the new DCS systems and increase in available data to the operator through the new systems.

The new systems increased both information and control capabilities. Both technical and operations personnel indicated that installation of the DAS prior to the DCS allowed valuable on the job pre-training in the use of the IA systems prior to controls replacement.

Operations personnel were utilized for the majority of controls and information displays construction (See attached examples.). Both operations and technical personnel indicated that this was a very successful and recommended method. A unit operator was designated as the primary authority for screen changes and construction. Modifications to controls and information screens were coordinated through or completed by that operator. Operators indicated that display design varied significantly from standard Foxboro displays. A primary goal of the Bonanza screens was to get anywhere needed with one mouse click. Touch screens were installed, but operators preferred the mouse and keyboard interface.

The simulator was purchased from Esscor which is a sibling company to Fxoboro under Invensys. Bonanza chose to purchase and Esscor "kit" simulator and build the simulator system internally. The simulator was completed about 1 to 2 months prior to the major unit outage wherein the primary controls systems would be replaced. It was used successfully for pre-tuning the new controls. Bonanza personnel recommended having the simulator completed about 1 year prior to controls to allow for more operator training and better development of tuning.

The new DCS and DAS systems at Bonanza are considered different components of the same system. Systems modification projects and overall engineering responsibilities are handled by systems and controls engineers. System maintenance responsibilities are handled by I&C personnel. With IA installed plant-wide as the DCS standard, new and continued training requirements for I&C personnel has been streamlined. All I&C personnel were trained on IA and Allen Bradley. However, specific I&C personnel are assigned to specific areas of responsibility. Since all equipment is the same, technicians with one area of responsibility can support most repair in other areas. Support for complex after-hours or weekend problems in areas outside of the shift I&C personnel's primary area of responsibility could be escalated by means of "on call" support by engineering or I&C personnel primary to a given system. Bonanza personnel indicated that allowing technicians to migrate to specific areas per interest and expertise had resulted in greater ownership in their jobs and areas of responsibility.

They would like to eventually rotated everyone through the DCS support. But, there are no plans to do this in the short term future.

Changes to the on-line systems are completed by either the engineers or technicians assigned with primary support for a given system. Typically, there will be one (1) or two (2) engineers and two (2) technicians with primary authority for any given area. Changes on a system could not be implemented without review of one (1) or more of this primary support group for a system. Once a change has been made, procedures include providing notification and updated documentation for the change to other engineering and I&C personnel.

Bonanza personnel were pleased with the new Foxboro IA systems and with Foxboro support. They indicated that both installation project support and post installation support have been very satisfactory.

Attachment # 3 - Notes on Navajo Plant Visit

# Fact Finding Tour
# DCS & DAS Replacement Project
# Salt River Project - Navajo Generating Station

**Visit to SRP's Navajo Power Plant: 27-Sep-00 Notes: J. Burr**

**Reason for upgrade:** Navajo upgraded because of obsolescence of old hardware, and installation of new scrubbers. Previously they had an old Bailey 820 analog control system with GE Turbine controls. They had a turnkey contract with Foxboro that covered installation of equipment over 3 years starting in 1997. First they replaced their DAS (information system). They upgraded 3 units. The first was done in 1997, the second in 1998, and the last in 1999. Each was done in under 8 weeks during an outage.

**Systems they looked at:** The corporate office did the spec, vendor selection, and contract. Foxboro was chosen, but Honeywell, Bailey, and Westinghouse were considered. The control system at SRP's Coronado Plant was replaced with Honeywell shortly before Navajo's project. It was reported things haven't worked out as well (with Honeywell) as with Foxboro. SRP has since used Foxboro on several other plant upgrades.

**Systems upgraded:** In 1997 they began with DAS systems. (Previously, they had an old Honeywell information systems). This required a new link to their old controls, which became unnecessary after controls and DAS were all Foxboro I/A and there were 500 points not needed. The cost was ~$16 million for unit and scrubber controls for 3 units. What was in 16 Bailey cabinets is now in 3 Foxboro cabinets. After the DAS, the Scrubber controls, BMS, DCS, turbine, SER and annunciator done all at once.

**Turbine controls:** These are now done in Foxboro and they work well. They have had very few problems with the new controls done by Foxboro. The controls for the BFP turbines are done with Woodward and interface with Foxboro. They said Woodward's support isn't so great and would like to replace the controls with Foxboro I/A.

**SER**: (Sequence of events recorder, or SOE) Replaced with Foxboro. They use the "causes of trips" only and have 50-100 points. Other items are alarms. They have a 3rd party package (Logmate) to determine sequence on a CRT.

**Sootblowing:** This is done with previously existing Allen Bradley PLC 5. It is integrated to the Foxboro and use Fox graphics for operation. Operators decide what sootblowing is done, it is not automatic.

**O2 Measurement System**: They have a Thermox AMTEK system and are happy with it.

**PLCs vs DCS controls:** They have power block logic for motor control of fans, pumps, etc done with Foxboro controls rather than PLCs. They recommend this in the main area of the plant. It is a more reliable way to do the control. They also use Foxboro in their scrubber controls rather than PLCs.

**Control Board Replacement:** They removed their control board (BTG) and replaced it with an arrangement of CRTs. The big disadvantage noted by operators was that they couldn't see as much at once with the screens. But overall the unit operators indicated that they liked the new controls and layout better. In the control room they had 5 workstations with 2 screens each for the main plant controls. They also 4 other screens for Alarms, plant LAN, and 2 scrubber/back end screens. There are direct-wired trip buttons for critical equipment. They have touch screens but do not recommend them or use them much, except the touch screens help to locate the cursor on the screen quickly. They would like the cursor to be more visible. Also the desk part of the station in front of the CRTs and keyboard should be larger for writing. Operators felt like the CRT stations should be in more of a U shape to help view things quicker. They used trackballs and were pleased with them.

Termination cabinets were installed in place of the BTG control board to handle wiring that had come directly to the board. Operators used a basic-generic simulator for training from Esscor but they were not pleased with the usefulness of this. The Foxboro controls guy, John Benoyer came and did a 2 week school for the operators. Initially only one unit was on the new control system, followed by another unit each year. Most of the operators preferred to work on the with the new controls once they became familiar with them.

**New Control Operation:** The new controls require little intervention and are not operated in manual as much. The unit operators operate the scrubbers from the main control room now, and normally requires as much time as running the units. The new controls are very stable, and handle runbacks very well. Ramp rate was 5 mw/min before and now do 75 mw/min is possible.

**More on software:** Foxboro provided a program for operators called "Operator Watch". Also they had an annunciator software program from Foxboro called "WASP". When a big upset in the unit occurs, up to 200 alarms may come in. Smart alarming is available but has not been configured. This should have been done up-front. Foxboro also provided a starting and loading program for unit startups. For maintenance issues, Foxboro has a preventative maintenance package which includes equipment runtimes.

**Graphics:** Graphics were built in Foxboro's "Display Manager" product, Foxboro now has a new product out called "Foxview". They used Foxboro's standard screen layouts for controls, which allow up to 8 control face plates on a page in combination with trends of other items in any of the 8 locations. They use face plate pages during normal operation, but use lots of process graphics during startups/shutdowns. The graphics were built mainly by operators.

**Historian:** They use the Foxboro legacy historian (not Aim-Star) for the control room but have an additional package called RTX (similar to PI) for engineers and managers to access plant data.

**Simulator:** The plant wanted a simulator from Esscor at the time the project was beginning, but could not get approval from all participants in the plant. They now have that approval and are proceeding to procure one. They indicated, a simulator would have been a big benefit prior to the installation and startup of the controls.

**System layout**: They have 3 processors dedicated to the DAS (information) and 11 control processors all of which are redundant. The make have a rule not to control with DAS points, so they only use control points.

**Support of System**: They maintain and support the system with a small group of dedicated people, none of which were engineers. The engineers they currently have at the plant don't work much on the controls. The people working on the system volunteered to for the project before it began. They have a system administrator (a former unit operator) who was a former unit operator, and 2 or 3 I&C techs dedicated to the new system. An additional tech was just reassigned to another plant. These people are still hourly and they maintain the system out to the field wiring. There have been some problems lately with technicians who are not working on this system feeling they are missing out. The system technicians we talked to, indicated that a high level of expertise ( training and hands-on experience) is required to support the system. They said this takes years, not weeks, to acquire. Hardware failures are very rare after startup, and when techs are called out, the problem is usually due to field problems. Control system changes are done rather informally. Changes are discussed with technicians, operators, results people, and engineers, then implemented.

**Project Management:** The spec and contract was done by the corporate office in Phoenix. Personnel at Page oversaw the installation and startup. Early in the project, engineers from the corporate office inventoried all control and wiring cabinets including everything in the control panels. During the installation contract people were used for wiring.. They contracted with Forney Systems to move their burner management system to Foxboro I/A. They specified to Foxboro, that Fox engineer John Benoyer to do the controls configuration. This was because they were familiar with him and he is one of the best. They indicated much of the success of the controls depends on the person that does them. The scrubber controls were done by the contractor for the scrubber (using Foxboro I/A) and they are less pleased with them. They have a full service maintenance agreement with Foxboro for ~$240,000 per year.

**Comments on Foxboro:** Very good hardware. They are pleased with the system and startup. Unlike Bonanza. they mostly used standard Foxboro graphics for control, configured to their needs. They have some Foxboro Cluster I/O for some cabinets. It is cheaper but will not function in hot environments. Also, they have had problems with connectors coming loose. They use UNIX for an operating system , and do no recommend using NT.

**Personnel:** Bob Swapp, system administrator, former unit operator
Willie Barber I&C tech
Jim Mace I&C tech

**<u>Visit to SRP's Navajo Power Plant: 27-Sep-00 Notes: K. Nielson</u>**
IPSC Attendees: James Burr, Ken Nielson, Alan Williams, & Bill Morgan

Navajo replaced DCS and DAS systems with Foxboro IA, Allen-Bradley is the PLC standard, and RTX is the off-platform plant historian. Retained Woodward for BFPT controls, but trying to migrate to Foxboro. CCS replacement precipitated by scrubber project. Previously, had Bailey controls w/Forney burner management system. New DCS allowed elimination of unit control boards, reduced required operator staffing, and increased DAS/DCS capability. 3 year project done by unit w/DAS & DCS replaced at same time. Simulator not purchased initially, though now approved for installation. Strongly recommended installation of Simulator prior to the DCS. Navajo was pleased w/ new Foxboro IA systems and support. Further detail is available below.

**<u>Navajo Site Visit Details</u>**
The following list of questions was compiled to review during the site visit:

1. Why were the old systems replaced?
2. Was the replacement system installed in a single phase or multi-phase project?
3. How was the replacement project done?
4. Was an independent Data Acquisition System (DAS) installed?
5. Was the DAS system done at the same time as the Coordinated Control System (CCS)?
6. Did they do the controls or take old controls and transfer them?
7. How long did it take to do the new controls?
8. Who configured the process graphics and operator interfaces?
9. Was a simulator installed?
10. Where in the project chronology was it installed?
11. How was the simulator done?
12. How were operators and system users trained?
13. With operators trained, how much continuing training is done?
14. Is the simulator used to test 'what if' scenarios for the CCS?
15. Were control rooms modified with the new CCS? If so, how?
16. How is support staffing structured for the new DCS, DAS, and Simulator systems?
17. How were support personnel trained?
18. Which/What replacement system(s) were selected? Why?
19. How successful and accepted has the replacement system been?
20. How was replacement project support from the system vendor?
21. How has post installation support been?
22. Does the vendor offer continuing modernization/upgrade support plans?
23. Are these used?

24. What are the details of such this plan?
25. What would be done differently?

Discussions on the replacement project and recorded notes are organized below according to the pre-compiled question list shown above.

1. Why were the old systems replaced?
    a. Obsolete control systems and the scrubber installation project precipitated the replacement of their control systems.
    b. Navajo had obsolete Bailey controls on their units. Unit control panels were all manual which limited the availability of this information.

2. Was the replacement system installed in a single phase or multi-phase project?
    a. Multi-year project with installation synchronized with the installation of the scrubbers beginning in 1997 and ending in 1999.
    b. DAS and DCS systems on a given unit were replaced at the same time during outages to implement the newly installed scrubber systems.

3. How was the replacement project done?
    a. Replacement was synchronized with the outages required for scrubber implementation.
    b. Did project one unit per year over three years. Each unit was done within an eight (8) week outage.
    c. Went from Bailey to Foxboro IA. I/O for the control systems was also changed to IA nodebus technology.
    d. On BFPT controls, Navajo is moving from MAC to Woodward, but would like to migrate all controls to Foxboro.
    e. Sootblowers are allen Bradley (Coal Slocum?). IA is connected through an integrator. Sootblowers starts are not automatically initiated, but rather initiated by Operator action.
    f. Replaced 16 Bailey cabinets with 3 Foxboro cabinets.
    g. Foxoboro IA 51B systems were installed.

4. Was an independent Data Acquisition System (DAS) installed?
    a. Yes and No.
    b. Each unit has a separate IA system. Though part of the same IA system, there are dedicated DAS and DCS components.
    c. During installation, the DAS portion of the system was installed first, then the DCS. Since the DAS and DCS systems started separate but are now essentially part of the same system, a rule of thumb is applied that controls are only done on and from controls points/components and data functions are loaded only on the DAS components/points.
    d. Prior to the IA system, no sequence of events recorder was available except for light box windows. This was all replaced by Foxboro IA. This system replaced a 775 point annunciator plus an additional 700 points.
    e. Foxboro has a package called WASP (Window Annunciation Software Package) which is the virtual creation of light box windows on a CRT. Users can click on a virtual light box for information on that point. Navajo has the WASP system; but instead of the WASP, they use a plant overview display with a blinking equipment primitives to indicate troubled equipment or conditions. They find this to work better than the annunciation windows or simulated windows.
    f. The sequence of events capability in IA is millisecond. But they indicated taht care needed to be taken that the SOE is not configured faster than the actual point updates.
    g. Navajo has 52 points configured for SOE. These are points for parameters or equipment that will cause a unit trip. Everything else recorded in the regular IA system for determining what happened after a trip and in what order.

h. DAS is a rolling historian. Navajo uses the "legacy" IA historian.
i. RTX is their long-term, "off-platform" archive system with 2 second resolution. Mostly provides process trends and includes an Excel interface. RTX is a company that was built by former Foxboro persons.
j. All RTX servers are located in the unit control building in a computer room back of the unit control room.
k. They have other Foxboro software or applications packages for preventative maintenance and run-time totalization, reports, etc.
l. Will be replacing their alarm printers with PCs using "Logmate" software.
m. Fiber optic links connected the scrubber and unit IA nodes.
n. Inter-unit connection is available to authorized personnel on the IA system although this option is used only when necessary. Navajo implemented a rule of thumb that controls changes to be done for a specific unit should be done on and from IA application workstations on that unit even though interconnection to APs from other units was possible.

5. Was the DAS system done at the same time as the Coordinated Control System (CCS)?
   a. Yes, the DAS was replaced during the same outage as the DCS on a given unit. However, during the outage, the DAS was installed first, then the CCS. A second DAS system was installed during a later 2 week outage.
   b. Problems with going with the DAS first is the need for intermediate links to the old system that will then be discarded when the balance of the old equipment is replaced.

6. Did they do the controls or take old controls and transfer them?
   a. John Benoyer (Venoyer) of Foxboro did their unit controls.
   b. Scrubber controls were done by SWE and ABB who received the hardware from Foxboro and did the controls themselves.
   c. On controls, Foxboro used a model from Texas Utilities for basic controls model. Then the controls were adapted to the specifics of the Navajo units.
   d. Burner management was done on IA by Forney. Forney just took what was in the old system and rebuilt those burner controls in the IA system.
   e. Philosophy generally followed by Navajo is that no equipment is started automatically. This is primarily for safety.
   f. IA has a good modicon interface, but there is some slow down in the scan rate with any interface and each interface to another system requires an "integrator" device (or gateway which introduces not only the slow down, but an additional point of failure.
   g. Troubleshooting all done in software on IA

7. How long did it take to do the new controls?
   a. Installation was done during an eight (8) week outage. However, a significant amount of pre-configuration of controls was completed by Foxboro.
   b. Installed and initially tuned during unit outages for installation of the new scrubbers.

8. Who configured the process graphics and operator interfaces?
   a. Navajo personnel built own displays on the DAS system using Foxboro face-plates for control.
   b. Display Manager by Foxboro was used. Foxboro now has the FoxView package which has a greater capability for customization.
   c. Displays were largely built by an operator on the installation group. That individual remained in the IA support group.

9. Was a simulator installed?
   a. No and Yes. No simulator was installed prior to installation of the DCS/DAS systems.

However, Navajo has just recently approved a simulator.

b. Navajo personnel indicated that it would have been much better to have before startup.

10. Where in the project chronology was it installed?

a. Approved for purchase in the coming year.

11. How was the simulator done?

a. N/A

12. How were operators and system users trained?

a. Initial startup was done by the systems team.

b. Regular operators trained on the job during the start ups wby working in conjunction with the installation/systems team.

13. With operators trained, how much continuing training is done?

a. Thought that the use of the simulator would have prevented some unit trips and will help avoid trips in the future. Need to have operator s familiar/2nd nature on using the new DCS systems. The new systems handle most conditions in auto mode quite well. Lack of training caused some operators to take action during events when none was required. Continued training with the simulator was thought to help operators from over-reaction during process events.

b. Navajo systems personnel indicated that the simulator was necessary to keep people sharp. With the new control systems, problems and start-ups are much fewer and further between.

14. Is the simulator used to test 'what if' scenarios for the CCS?

a. As yet, N/A.

15. Were control rooms modified with the new CCS? If so, how?

a. All manual board components and the entire manual control panel previously in use at Navajo was replaced by the IA CRT command station.

b. Arrangement of CRTs included 14 CRTs in a bent or slightly curving formation. Six (6) CRTs were vertically, double-stacked in the center of the command station with an additional pair of CRTs vertically stacked on each flank. Each pair of these CRTs were supported by an IA workstation processor (WP). These ten (10) CRTs were dedicated to unit control and monitoring. On one end of the command station, an additional four (4) CRTs were mounted horizontally at eye level. The first two (2) were IA CRTs supported by one (1) WP. These were dedicated to scrubber control. The next CRT was PC connected providing access to the plant LAN and maintenance management system. The final CRT was for an IA application processor. An additional two CRT sized panels with hardwired buttons for operator action were located in the operator command station. These included hardwired unit and turbine trip buttons. Trackball and mylar keyboards were provided for each system pair of WP CRTs. Two (2) alarm printers and a tagging PC were place adjacent to the command station and available for unit operator use.

c. As the DCS was replaced and operators came up to speed, the operators have preferred the new IA systems to the control panel.

d. Application and workstation processors were UNIX workstations.

e. Though used initially after the scrubbers came on-line, scrubber control rooms are no longer used.

f. Each unit operator handles a portion of the outside area controls. There are three units; hence, three UOs with a control command station as descibed above per unit. Each UO has one or two auxiliary operators available assist as required.

16. How is support staffing structured for the new DCS, DAS, and Simulator systems?
   a. Met with the three (3) systems personnel: Bob Swapp, Jim Mace, and William Barber.
   b. Two (2) came from I&C and one (1) from Operations. The individual from Ops. did the graphics, then was assigned system administration. The two (2) technicians from I&C technicians worked with Foxboro on the controls and now are responsible for controls changes and maintenance. They are no longer part of I&C or Operations.
   c. They had four (4) systems people initially, but one has since transferred SRP central office in Phoenix.
   d. They strongly recommended a closed system support group due to the learning curve involved with the systems. They handle support issues and controls changes.
   e. Then they turn problems that deal with the field devices to I&C for action.
   f. When questioned about support depth and after-hours support, they indicated that as yet there had been no problems. Some after hours support issues were handled on a call-out basis.

17. How were support personnel trained?
   a. All systems personnel were fully trained at Foxboro. The two I&C systems technicians do all controls modifications.

18. Which/What replacement system(s) were selected? Why?
   a. New system are all Foxboro IA for CCS, turbine, and burner controls. This has been a benefit as replacement parts are homogeneous.
   b. Honeywell, Bailey, Westinghouse, and Foxboro were all bid competitors on the project. Foxboro won with low bid.
   c. Unix is recommended over NT for the control system operating system. Their opinion was that UNIX was more secure and stable for this type of application.
   d. Allen Bradley is their PLC plant standard (Model 540)
   e. Navajo uses Tri-Sen controllers for the turbine valve servos.
   f. All plants with the Salt River Project are upgrading their coordinated control systems. The first was Coronado that went with Honeywell. That system, while successful in meeting project goals, has been less than satisfactory in overall performance in comparison for Foxboro which has been the selected standard for other SRP plants.

19. How successful and accepted has the replacement system been?
   a. The new DCS didn't effect NOx output.
   b. Improved ramp rate form 5 MW/min to a typical capability of 50 MW/min and a maximum capability of 75 MW/min.
   c. While initially uncomfortable with the CRT based control panel, all operators indicated that they now thought they were better than the panels they replaced. Different techniques and methods of information and controls management was required by the operators in using the CRT base systems.

20. How was replacement project support from the system vendor?
   a. Foxboro support has been great. Excellent system engineering, installation support, and hardware support.
   b. Used Foxboro for replacement of I/O wiring. This turned-out very well.
   c. Navajo indicated the greatest level of satisfaction in the segments of the project completed in which Foxboro was the primary contractor.

21. How has post installation support been?
   a. Reported very satisfied with Foxboro support.

b. They have a "Foxwatch" support contract.
c. Support cost per year with Foxboro is +$240,000.

22. Does the vendor offer continuing modernization/upgrade support plans?
    a. Navajo not utilizing this type of service from Foxboro. However, they recommended that such upgrades during the installation phases might be addressed in the specification to ensure all components and/or software up to date at the conclusion of the installation project.

23. Are these used?
    a. At present they are not using such as service from Foxboro.

24. What are the details of such this plan?
    a. N/A

25. What would be done differently?
    a. Cluster I/O has mixed review. Some problems w/ connectors staying attached and with bad I/O indication to the DCS. Cluster I/O in a bigger qty of I/O for a given space. If they were to do it over, they would use FBMs instead of cluster. Each card handles 64 digital or 16 ananlog inputs. It is somewhat cheaper. Cluster I/O cards are very heat intolerant.
    b. Operators at Navajo did not like the touch screens very well. Absolutely not used for start and stops on equipment or changes on set points. OK to use to find cursor and to change screen displays.

SUMMARY

The visit to the Navajo power station was very beneficial. Navajo had selected the Foxboro IA system for the replacement DCS system. This allowed IPSC personnel to focus on project issues, sequence, and technology transition issues rather than comparisons of different DCS vendor products. This was consistent with the intent of the visit.

The Navajo plant visit provided the perspective of a replacement project for the DCS and data acquisition systems in a larger plant/unit environment. While done over a multi-year project, DCS and DAS systems for a given unit were replaced during the same outage. This contrasted with the phase installation approach applied at Bonanza.

The Navajo DCS/DAS replacement project began in 1997 and was completed in 1999. It included the replacement of the I/O capability of the old systems. It also included the installation of DCS systems in the newly installed scrubber systems. These systems were also IA systems. A simulator was not installed prior to the DCS/DAS systems. One had been planned but installation was delayed by project participants. A simulator is currently approved for purchase and installation. It will be used to provide continued training for operations personnel and for testing of tuning and controls changes. Navajo personnel indicated that continued operator training with the simulator was considered essential as the new DCS systems minimized trips and unit events and accordingly minimized exposure to unit start-ups and event reaction training.

The DCS/DAS replacement project was initiated due to obsolescence and lack of capacity in the previous systems. These factors along with the project to install scrubbers on the Navajo units precipitated the installation/replacement of the DCS systems. Foxboro was selected as the replacement for the boiler, turbine and burner control systems. The previous systems included Bailey and Forney. Allen Bradley is their PLC plant standard (Model 540). Navajo uses Tri-Sen controllers for the turbine valve servos. BFPT controls are being moved from MAC to Woodward, but they would like to migrate all controls to Foxboro. Sootblowers are Allen Bradley (Coal/Cole Slocum?). IA is connected through an integrator. Sootblowers starts are not automatically initiated, but rather initiated by Operator action. Navajo systems personnel indicated that the replacement of the previous systems with Foxboro systems had streamlined spare parts and support issues.

The DCS replacement project also caused replacement of the manual-switch control boards. Control room monitoring capability now includes a CRT based control panel for operator interface. Operations personnel indicated that the use of CRTs for control and elimination of the manual control boards was a significant change, but was successful and now largely preferred. However, they indicated that the usefulness of touch screens was limited to locating the cursor. Operators indicated that the CRT based control panels introduced some challenges to get "at–a-glance" status of the operating units as compared with the manual control panel. With use and training, however, they had come to prefer the CRT based systems. They also indicated that greater quantities of data could be viewed from the CRT based panels than was available from the manual control panels.

Monitoring of processes from remote or back-end control rooms started in the remote area control rooms. It had since been relocated to the main unit control room. Unit Operators had auxiliary operators available to assist with unit control. Like Bonanza, they indicated that the added responsibility of monitoring back-end and outer area operation from the main control room had not impeded their ability or quality of control. They attributed this to the improved control capabilities of the new DCS systems and the increase in available data to the operator through the new systems.

Similar to Bonanza, the new systems increased both information and control capabilities. System support personnel indicated that the installation of a simulator prior to the DCS/DAS system would have allowed valuable pre-replacement training for operations personnel.

An operations person was utilized to configure the controls and information displays (See attached examples.). Both operations and technical personnel indicated that this was a very successful and recommended method. This person was later designated as the DAS administrator and the primary authority for screen changes and construction. Display design followed largely the Foxboro face-plate style. Touch screens were installed, but operators preferred the mouse and keyboard interface.

The DCS controls changes and administration was completed by the two (2) systems technicians. They were originally from the I&C department. The three (3) systems support personnel formed a defacto IA systems support group. Foxboro was also retained under maintenance contract for additional system maintenance support. There are currently no plans to rotate support other personnel through the DCS/DAS system support group.

Navajo personnel were pleased with the new Foxboro IA systems and with Foxboro support. They indicated that both installation project support and post installation support have been very satisfactory.

Attachment # 4 - Alternative Project Schedules

## DCS Replacement Timetable w/ Accelerated Simulator Schedule

| Calendar Year | * Denotes Approximate Date of Annual Major Outage<br>2000 Jul · 2001 Jan · Jul · 2002 Jan · Jul · 2003 Jan · Jul · 2004 Jan · Jul · 2005 Jan · Jul · 2006 Jan · Jul · 2007 Jan · Jul · 2008 Jan | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Budget Year** | FY2000-2001 | FY2001-2002 | FY2002-2003 | FY2003-2004 | FY2004-2005 | FY2005-2006 | FY2006-2007 | FY2007-2008 |
| **FOX 1/A Replacement Schedule** | Continued Technology investigation | Complete preliminary engineering, budget, and develop project specifications, issue RFP, Select Vendor. | [redacted] | [redacted] | *Alternative Deferred Schedule - Project completion in 2004-05* | *Alternative Deferred Schedule - Project completion in 2005-06* | *Alternative Deferred Schedule - Project completion in 2006-07* | 12/31/07<br>New NOx Requirements on 12/31/2007 Replacement must be completed prior to NOx deadline. |
| **Accelerated Simulator Replacement Schedule** | | Budget/Spec for Simulator | [redacted] | [redacted] | [redacted] | [redacted] | | |
| **CCS, Turbine, BFP, and Burner Managment Systems Replacement Schedule** | | | *Accelerated Replacement Schedule - Accelerated 2 years.*<br>Beginning of controls replacement could be accelerated to this point with the delivery of a turn-key simulator system. | *Accelerated Replacement Schedule - Accelerated 1 year.*<br>Controls expansion, coordination w/DAS replacement, or CCS reliability problems may require acceleration of replacement.<br>Replacement must be completed prior to NOx deadline. | Budget for CCS, GE, Bailey, BFP, and SER replacement systems hardware. | [redacted] | [redacted] | |

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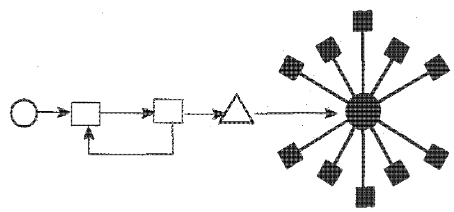
# DCS Replacement Timetable w/ DCS Schedules

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Calendar Year | | ** Denotes Approximate Date of Annual Major Outage*<br>2000 Jul, 2001 Jan | Jul, 2002 Jan | Jul, 2003 Jan | Jul, 2004 Jan | Jul, 2005 Jan | Jul, 2006 Jan | Jul, 2007 Jan | Jul, 2008 Jan |
| Budget Year | | FY2000-2001 | FY2001-2002 | FY2002-2003 | FY2003-2004 | FY2004-2005 | FY2005-2006 | FY2006-2007 | FY2007-2008 |
| ACCELERATED 1 YR | **FOX 1/A Replacement Schedule** | Continued Technology investigation | Complete preliminary engineering, budget, and develop project specifications, issue RFP, Select Vendor. | [redacted] | [redacted] | *Alternative Deferred Schedule - Project completion in 2004-05* | *Alternative Deferred Schedule - Project completion in 2005-06* | | ⇧<br>12/31/07<br><br>New NOx Requirements on 12/31/2007 Replacement must be completed prior to NOx deadline. |
| | **Accelerated Simulator Replacement Schedule** | | Budget/Spec for Simulator.<br><br>Budget for delivery of controls logic for CCS, GE, Bailey, BFP, and SER systems. | [redacted] | Operator Training | | | | |
| | Accelerated Controls Replacement Schedule | | | *Accelerated Replacement Schedule - Accelerated 2 years.* | Budget for CCS, GE, Bailey, BFP, and SER replacement systems hardware. | [redacted] | [redacted] | | |
| ACCELERATED 2 YRS | **FOX 1/A Replacement Schedule** | Continued Technology investigation | Complete preliminary engineering, budget, and develop project specifications, issue RFP, Select Vendor. | [redacted] | [redacted] | *Alternative Deferred Schedule - Project completion in 2004-05* | | | ⇧<br>12/31/07<br><br>New NOx Requirements on 12/31/2007 Replacement must be completed prior to NOx deadline. |
| | **Accelerated Simulator Replacement Schedule** | | Budget/Spec for Simulator.<br><br>Budget for delivery of controls logic. | [redacted] | Operator Ttraining | | | | |
| | Accelerated Controls Replacement Schedule | | | Budget for CCS, GE, Bailey, BFP, and SER replacement systems hardware. | Purchase and Install U2 CCS, GE, Bailey, BFP, and SER replacement systems. | Purchase and Install U1 CCS, GE, Bailey, BFP, and SER replacement systems. | | | |

INTERMOUNTAIN POWER SERVICE CORPORATION



# DCS Replacement Project

## Summary of Findings

DCS Replacement Project Working Group
James Burr
Bill Morgan
Ken Nielson

Technical Services Department
Intermountain Power Service Corporation

**November 2000**

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## EXECUTIVE SUMMARY: DCS Systems Status and Future

Overview

The DCS Replacement Project Working Group was assigned to review the status of existing control and process data systems at the Intermountain Generating Station (IGS) and develop recommendations to ensure the long term viability of control system functions. The findings of this review are found in this document.

Included Systems

1. **Process Data Systems**
   a. FOX 1/A computer systems
   b. Plant Data Systems: PI Plant Information Systems
2. **Process Control Systems**
   a. Foxboro Videospec and Microspec systems
   b. GE Turbine Automatic Controls (TAC), Turbine-Generator Supervisory Instrumenation (TGSI), Electro-Hydraulic Control (EHC), and the MDT20 BFPT Control systems
   c. Rochester Information System (RIS)
   d. Bailey burner control systems.
3. **IGS Controls Simulator -** Training and Controls Testing System

Status & Condition

The primary concerns facing the plant process data and control systems are obsolescence and lack of expansion capacity.

The FOX 1/A systems are experiencing increasing levels of failure and difficulty in obtaining replacement components. While the impact of these failures has been minimized to date, system trends are towards increased rates of failure. Decreasing system reliability is likely to have an increased impact on unit operation.

The PI system uses newer technology. Obsolescence and spare parts availability are not currently problems, but there is some indication of upcoming issues in these areas on PI-Home. Long range plans are in place to meet those concerns through the PI Migration Project. Investigation was made into the possibility of consolidation of PI functions with a future DCS system. However, current DCS systems do not adequately provide the historian and analysis capabilities of PI. Continuation of PI as a separate, plant wide system is recommended.

The Foxboro, Bailey, and Rochester control systems are still operating reliably. Some problems with spare parts availability have been encountered and solved. However, these systems are the same generation of equipment as the FOX 1/A systems, and it is expected that the problems currently experienced on the FOX 1/A systems are a precursor to the future on the control systems.

The General Electric (GE) turbine controls systems are currently experiencing failure and reliability problems with TAC systems most affected. Increasing failure and reliability problems are expected on these systems.

IGS currently has no simulator system for training or controls testing.

Proposed Replacement Sequence & Schedule

It is proposed that a multi-year capital project be initiated to replace the IGS process data and control systems beginning with the FOX 1/A systems followed later with the control systems. See the recommended sequence and schedule below:

1. **FOX 1/A Systems**
   FOX 1/A replacement is recommended for the initial phase of the project beginning with Unit 1 in 2002-03 and concluding in 2003-04 on Unit 2. These systems stand the greatest risks of failure. Reasons for replacement are:
   a. System reliability is a critical concern. Systems suffer from increasing failure rates. Delay of FOX 1/A replacement will likely reduce availability of alarming, AGC control, permissive screens, and process graphics in the control room.
   b. Outage window constraints as currently planned will not allow complete DCS replacement on a single unit during a single outage.
   c. FOX 1/A replacement prior to the controls will allow operations personnel to gain experience on the DCS hardware prior to being required to use the same type of hardware for unit control.
   d. The phased replacement of the DCS systems will reduce dependence on contractor labor and lower the overall project cost.

2. **Simulator**
   The installation of a simulator is recommended to begin in 2003-04 with completion no later than 2004-05. Completion of a simulator is required eight (8) to twelve (12) months prior to the controls in order to realize the full benefits. The benefits of a simulator are as follows:
   a. Controls can be developed and tested prior to installation of the control systems. This will minimize the post-outage start-up time.
   b. Operations personnel can be trained in advance on the new controls to ensure high availability with the new systems.
   c. Operational equipment scenarios with alternative controls solutions can be tested by Operations and Engineering.
   d. Other appropriate support personnel can be trained in advance.

3. **Controls: CCS, Turbine, BFP, and Burner Management Controls; Sequence of Events Recorders; Flame Scanners; and, Overall Systems Optimization**
   Replacement of the controls is recommended for the final phase of the project. First unit installation is envisioned for 2005-06 with the second unit following in 2006-07. Replacement is essential for the following reasons:
   a. The current systems are at capacity. New controls hardware will be required for the NOx reduction project.
   b. The existing systems are becoming obsolete. Unacceptable levels of reliability and availability are expected.

Deferral of the FOX 1/A replacement is possible but not recommended for reasons explained in greater length in subsequent sections of this document. The installation of a simulator and new controls systems cannot be deferred beyond the recommendations of this report, however acceleration of these phases is possible if warranted. A recommended schedule is found on page 3.

# RECOMMENDED DCS REPLACEMENT TIMELINE

| Calendar Year | * Denotes Approximate Date of Annual Major Outage<br>2000 Jul · 2001 Jan * · Jul · 2002 Jan * · Jul · 2003 Jan * · Jul · 2004 Jan * · Jul · 2005 Jan * · Jul · 2006 Jan * · Jul · 2007 Jan * · Jul · 2008 Jan * | | | | | | |
|---|---|---|---|---|---|---|---|
| Budget Year | FY2000-2001 | FY2001-2002 | FY2002-2003 | FY2003-2004 | FY2004-2005 | FY2005-2006 | FY2006-2007 | FY2007-2008 |
| FOX 1/A Replacement Schedule | Continued Technology investigation | Complete preliminary engineering, budget, and develop project specifications, issue RFP, Select Vendor. | [redacted] | [redacted] | *Alternative Deferred Schedule - Project completion in 2004-05* | *Alternative Deferred Schedule - Project completion in 2005-06* | *Alternative Deferred Schedule - Project completion in 2006-07* | ⇧<br>12/31/07<br>New NOx Requirements on 12/31/2007 Replacement must be completed prior to NOx deadline. |
| Simulator Replacement Schedule | | *Alternative Replacement Schedule.*<br>Completion of Simulator required a minimum of one (1) year in advance of CCS replacement. | Budget for Simulator | [redacted] | [redacted] | [redacted] | | |
| CCS, Turbine, BFP, and Burner Managment Systems Replacement Schedule | | | *Accelerated Replacement Schedule - Accelerated 2 years.*<br>Beginning of controls replacement could be accelerated to this point with the delivery of a turn-key simulator system. | *Accelerated Replacement Schedule - Accelerated 1 year.*<br>Controls expansion, coordination w/DAS replacement, or CCS reliability problems may require acceleration of replacement.<br>Replacement must be completed prior to NOx deadline. | Budget for CCS, GE, Bailey, BFP, and SER replacement systems. | [redacted] | [redacted] | |



IP12_013499

## OVERVIEW of RECOMMENDED SCHEDULE

Year 1: Fiscal Year 2001-02

1. Complete preliminary system engineering.
2. Complete investigation and define preferred technology for DCS replacement systems.
3. Develop specifications for replacement Data, Control, and Simulator Systems.
4. Submit specification with requests for proposals to DCS vendors.
5. Evaluate proposals and select vendor.

Year 2: Fiscal Year 2002-03

1. Purchase and install DAS system (FOX 1/A replacement) for Unit 1.
    a. Receive, stage, and pre-test the U1 system.
    b. Complete training for support personnel and system users on tested system.
    c. Complete full installation during four (4) week U1 outage.
2. Complete final specifications and preparations to begin simulator project.

Year 3: Fiscal Year 2003-04

1. Install Unit 2 DAS system.
    a. Continue DAS system user training.
    b. Receive, stage, and pre-test the DAS system for Unit 2.
    c. Complete full installation during the four (4) week U2 outage.
2. Purchase Simulator system from selected vendor.
    a. Receive, stage, and test simulator hardware
    b. Receive Simulator kit from vendor and begin Simulator development

Year 4: Fiscal Year 2004-05

1. Complete Simulator development and testing of simulated unit models.
2. Check-out controls on Simulator
    a. Receive controls from DCS vendor
    b. Complete controls check-out.
3. Begin operator training.
4. Complete final specifications and preparations for controls replacement.

Year 5: Fiscal Year 2005-06

1. Complete operator training
2. Purchase and install DCS system (FOX 1/A replacement) for Unit 2.
    a. Receive, stage, and pre-test the U2 DCS system.
    b. Remove old system and complete DCS installation during four (4) week U2 outage.

Year 6: Fiscal Year 2006-07

1. Continue operator training.
2. Purchase and install DCS system (FOX 1/A replacement) for Unit 1.
    a. Receive, stage, and pre-test the U2 DCS system.
    b. Remove old system and complete DCS installation during four (4) week U1 outage.
3. Complete project close out and documentation.

## ESTIMATED COST for TURN-KEY SYSTEMS

The costs listed below are general estimates based on DCS vendor turn-key pricing. Under a turn-key project, the DCS vendor would provide the system hardware, software, project management, application engineering, field service, training, construction management, and installation.

| DCS Replacement Project Cost Estimate | | | | | | | |
|---|---|---|---|---|---|---|---|
| Budget Year | 2001-2002 | 2002-2003 | 2003-2004 | 2004-2005 | 2005-2006 | 2005-2006 | TOTALS |
| FOX I/A Replacement Costs | | $2,580,000 | $2,480,000 | $0 | $0 | $0 | **$5,100,000** |
| Simulator Replacement Costs | | $0 | $700,000 | $400,000 | $0 | $0 | $1,100,000 |
| Controls Replacement Costs | $40,000 | $0 | $0 | $0 | $2,850,000 | $2,750,000 | **$5,600,000** |
| Job Total | $40,000 | $2,580,000 | $3,180,000 | $400,000 | $2,850,000 | $2,750,000 | **$11,800,000** |

IP12_013501

## RECOMMENDATION for FOX 1/A SYSTEMS

Replacement of the FOX 1/A system is recommended as the initial segment of the plant DCS upgrade project. Replacement is recommended following a three (3) phase plan beginning in the 2001-02 budget year with completion scheduled for 2003-04. The replacement data acquisition system (DAS) should be selected to be compatible with the controls replacement system.

The obsolete nature of the FOX 1/A and the time in service of most system components have resulted in a trend of increasing system failures and reliability problems. This trend is impacting system availability. It is not expected to improve. Additionally, the processing and monitoring capability of existing systems is near capacity. Delay of FOX 1/A replacement is an option, but not recommended.

BENEFITS

The replacement of the FOX 1/A system would bring the following benefits:

1. **System obsolescence and reliability issues solved.** Removal and replacement of the existing system with new technology systems would eliminate the availability and reliability problems currently being experienced on the unit DAS systems.

2. **Improved unit monitoring capability.** New technology systems have vastly increased monitoring capability and analysis power, and these systems require significantly less floor space that existing systems. A replacement system would offer could be expected to supply more data, faster, and more reliably than the existing systems with significant expansion capability.

3. **Reduced long-term spare parts and support training costs.** Replacement systems would be selected that would be compatible with the controls replacement DCS systems and in large part use common spares. The current collection of varied systems would be replaced with an integrated system from a single vendor. Elimination of the need to train all systems personnel on a variety of systems would reduce training costs.

4. **Improved data to the plant information system.** The replacement DAS system would provide a standardized, higher capacity data link to the plant information system.

5. **Pre-training and experience in the use of the replacement DCS system technology.** The replacement FOX 1/A systems would use the same type of equipment as the controls replacement systems though implemented for data acquisition only. While this does not replace simulator/controls training, it provides operators with experience on the DCS replacement system hardware in advance of the DCS installation.

Every effort is currently being made to extend the service life of the FOX 1/A systems to the absolute end of OEM or third party support. Current trends, however, indicate that within three (3) to five (5) years such a course will likely result in a serious and extended system failure and a corresponding breach in the availability of measured process data and dependent analytical and predictive data. Accordingly, a project to replace the FOX 1/A should begin by 2001-02.

## RECOMMENDATION for SIMULATOR

Purchase of a modern high-fidelity simulator is recommended as part of a plant DCS upgrade. Currently many fossil utilities are investing in simulators to be competitive in a deregulated energy market. There are two main reasons: to improve plant operation, and to aid in changing to a new DCS. Advances in simulator technology have made it possible to have an exact model of a power plant's processes and equipment. This allows the simulator model to be controlled by a copy of the plant DCS software.

BENEFITS
The benefits of a Simulator are as follows :

1. **DCS control testing tool.** DCS controls can be configured, tested, debugged, and tuned on the simulator before the unit outage to change out the control system begins. This reduces the amount of work that needs to be done during the outage and can reduce the overall outage time. Fewer problems bringing the unit back online would be expected. The decrease in outage time could pay for the cost of the simulator.

2. **Operator training tool.** The simulator would allow operators to train on the new DCS before it is installed. The simulator representation of the plant and controls would be very realistic, and it would be an ongoing tool to keep operators "current" on scenarios that are not common during normal operation, helping to maintain high availability.

3. **Unit performance testing tool.** Using the simulator as a testing tool has allowed some plants to ramp faster, operate at lower/higher loads, and avoid trips. "What if" scenarios could be run on the simulator to investigate the results of different operating conditions, or equipment changes.

4. **I&C technician training tool.** The simulator would be a technician training environment for the DCS controls as well as the DCS hardware.

The simulator could be purchased as a turnkey system or as a kit. The "kit" option is the recommended approach. A kit system would involve IPSC personnel assisting the vendor in configuring the controls and plant model, as well as validation of the simulator at various load conditions. Likely, operators, I&C technicians, and engineers would be need to be assigned to do this work. The two options are described below:

1. **Kit Option.** A kit would cost about $700,000 and take about 2 years. It would cost about 65 % of a turnkey system. A kit offers the benefit that IPSC personnel would gain an intimate knowledge of the internal details of the simulator design and the plant controls. This knowledge is directly transferable to the control system software and hardware.

2. **Turn-Key system.** The estimated cost of a turnkey system is $1,100,000 and it would take 18 months to complete. The main advantage is a shorter project completion time, about 6 months shorter. Also, fewer IPSC personnel would be required to complete the project.

## CONTROL SYSTEM REPLACEMENT

Replacement of the present control systems must be completed prior to the NOx modifications which will be required by December 31, 2007. This is based on the need for additional control hardware for emissions reduction and obsolescence of the current equipment. The systems listed below are the main plant controls and would function more effectively as a single system. Installation of a unified control system will result in improved control capability. It will also reduce the amount of required hardware for the operator interface, result in decreased maintenance (single system with less hardware to maintain), simplify troubleshooting, streamline training, and a result in a reduction in warehouse inventory.

The following systems are recommended for replacement as part of the DCS upgrade:

1. Foxboro Videospec/Microspec combustion control system (CCS)

2. Bailey Net-90 burner controls system (BCS).

3. General Electric Mark IIA turbine controls (EHC), turbine generator supervisory instruments (TGSI), turbine automatic controls (TAC), and MDT-20 controls for boiler feed pump turbines.

4. Rochester AN-4100 and ISM-1 annunciator and sequence of events recorder (SER).

The present combustion controls (Foxboro CCS) have had several modifications over the last 14 years which have used spare hardware and software capacity. This will prevent any further significant changes to the combustion controls in the future without a major upgrade.

The General Electric (GE) systems have experienced multiple problems over the years. EHC failures have caused unit trips and TAC failures have occurred during critical times including unit startups. The TGSI systems have had problems with the disk/tape drives subsystem which has required an interim replacement. Additionally, the TGSI operating system is costly as well as cumbersome to modify. The boiler feed pump turbine controls have had problems with calibration drift which cause difficultly with the calibration lineup during outages. A further concern with the GE systems is vendor support. The number of GE personnel remaining who can support these systems is limited.

The Bailey Net-90 systems are becoming obsolete and are experiencing problems with the main processors (logic master modules). These modules are very sensitive to power spikes that cause the memory to be corrupted and require a reload of the operating parameters after system power is cycled.

A new, single control system could tie all of these systems together and provide redundancy, seamless intercommunication, ease of operation and maintenance, and increase the reliability of the unit operation. The enhanced control system will modernize the unit operations providing a new control console for the operators.

Recommendation for Foxboro Videospec/Microspec Controls:
Replacement of the Foxboro systems is recommended as part of the total controls replacement. As indicated above, these systems have no expansion capability. Also, long term vendor support is a

concern. We expect to be able to support this system through 2007; however, Foxboro has transferred support of this equipment to an outside company, Process Control Systems (PCS). While PCS has indicated a potential 10 year support for this system, that support is based on availability of spare parts. Additionally, some of the processor and i/o boards for these systems have custom modifications unique to IGS. This further complicates the support forecast. Parts availability has been a problem for the Foxboro FOX 1/A systems which is the same generation as the Videospec/Microspec. This may indicate that similar, future problem for the Videospec/Microspec. It is certain that the replacement of the Foxboro controls will be necessary well ahead of any regulatory deadlines that require controls modifications or enhancements.

Recommendation for Bailey Net-90 Burner Controls:
Replacement of the Bailey Net-90 Burner Controls is recommended as part of the final segment of the plant DCS upgrade project. This system controls the operation of the pulverizers through control stations on the main control panel. We can eliminate a large amount of hardware and software by combining this system with the main plant digital control system (DCS).

There have been numerous problems with this system over the years. A problem with the grounding in this system caused problems with the flame scanners which resulted in pulverizer trips on loss of flame indication. The Logic Master Modules (LMM) have extended startups due to a loss of program. Power supply failures have caused unit trips and required a modification to a redundant power supply system. It is expected that adequate support for the Bailey hardware will be available until the recommended replacement window. However, the current software used to interface with the Bailey system is obsolete. It is DOS/Windows 3.1 based and will require an upgrade in the near future.

Recommendation for General Electric EHC, TGSI, TAC, and BFPT MDT-20 Systems:
We recommend that the General Electric systems be replaced as part of the final segment of the plant DCS upgrade project. Combining the key control systems into a single system resolves numerous problems associated with the present system.

These systems are expected to be maintainable until completion of the DCS upgrade. But, there is some risk of further intermittent failure due to the remaining, unresolvable problems. The turbine controls have had problems with mercury wetted relays, test circuits that fail, and circuit board component aging causing drifting of settings. The information portion of the system, TGSI, has had problems with the data collection and historical portion of the system. The TGSI to FOX 1/A data link is antiquated causing the update cycle to the information computer to be in excess of four (4) minutes. Discussions with GE to improve upon this communications link have not resolved this situation due to the GE costs required to make changes to our old system (> $100K/unit). The TAC system has had problems since startup. These problems have never been resolved and GE only made ten of these systems due to the problems they encountered. The BFPT controls are an old vintage that are prone to drifting due to the discrete components on the circuit boards. All these systems have problems which would be resolved by replacing them as part of a main plant total DCS replacement.

As indicated earlier, a further concern with the GE systems is vendor support. The number of GE personnel remaining who can support these systems is limited. Also, the turn-around time on repairs and the quality of the actual repairs have been unacceptable in several instances.

Recommendation for Sequence of Events Recorder:
We recommend that the Rochester Sequence of Events Recorder be included for replacement as part of the plant DCS upgrade project. This final system will bring all the necessary information into a single system.

This system was upgraded approximately eight years ago to the current ISM-1 system for audible annunciation and sequence of events. Problems have continually plagued the system with lock-up of the system for no apparent reason. Several attempts by Rochester to repair this problem have not been resolved. This is a critical system when troubleshooting equipment or unit trips.

BENEFITS
The benefits of controls replacement with a coordinated DCS system are as follows:

1. **Improved Control Capability:** These newer systems have finer control capability which enable better control of the boiler, turbine and feed pumps. They have systems available to evaluate tuning parameters, for all control loops, to enhance total system operation. These systems can also be used as a troubleshooting tool to evaluate problems and help with determining resolutions.

2. **Load Ramp Improvement:** The newer controls have a better ability to control key parameters during a load change which allows a quicker load increase or decrease. This may be important in the future with a de-regulated market.

3. **Performance Enhancement:** An improvement in efficiency has been demonstrated in the new control systems. Even though we already have a high heat rate, improved performance will be seen with tighter control of pressure and temperature with the newer boiler controls.

4. **Reduced Hardware:** The newer DCS systems allow a reduction in interface equipment because of the direct connection of instrumentation through the DCS system. This means that recorders, switches, lights, control stations, and indicators will be wired directly to the DCS . This eliminates the equipment and the wiring.

5. **Training Standardization:** Having all the control in a single system minimizes the training requirements. Costs will be reduced and overall training needs decreased.

6. **Warehouse Inventory Reduction:** Total control parts inventory can be reduced significantly by combining systems into a single manufacturer for key control systems.

7. **Central Information Gathering:** All information from each system would come to the new DCS system. No special data interfaces would be required as they are now, ie. TAC, TGSI and SER data links. Current and historical data would be available for plant personnel to review and evaluate from a single source.

## POTENTIAL ECONOMIC BENEFITS

DCS vendors advocate that a new DCS would reduce generating costs and improve competitiveness in the following areas: improved megawatt ramp rate, O2 improvements, sootblowing reduction, improved availability, reduced maintenance costs, reduced inventory costs, reduced NOx emissions, improved productivity, and lower training costs. Of these, megawatt ramp rate, and improved availability are thought have the largest potential dollar value:

1. **Improved ramp rate:** Many western utilities are upgrading control systems with increased unit ramp rate being a primary objective. An improved ramp rate allows them to be more responsive to dispatch demands and competitively capture "spot market" power sales and higher market prices. IPSC engineering personnel do not have the necessary marketing information needed to estimate the potential benefit of an increased ramp rate.

2. **Improved availability:** A new DCS could be expected to improve availability due to fewer future trips, fewer runbacks, and shorter startup time after trips and outages. The potential benefit could be significant considering that trips and reduced availability are expected to increase as the existing control equipment ages. No estimates for the value of potential benefits have been made.

**Maintenance Costs:** Maintenance costs on a new system would likely not be less than what IPSC is experiencing now. Past costs have averaged $69,000 over the last 4 years to maintain the Fox 1/A, CCS, RIS, Bailey Net 90, and GE systems. This number was identified from purchase order information ( purchases, repairs, rebuilds) assigned to control system equipment codes. Likely, there are some costs that were assigned to the plant equipment numbers rather than the control system equipment numbers and are not reflected in the above total. The table in "Attachment A", Summary of Current System Maintenance Costs, shows that the Fox 1/A accounts for most of the yearly cost.

Future costs would depend on the level of support that IPSC desired from the DCS vendor, but they could be estimated to be from $100,000 to $200,000 per year. This is based on the maintenance agreements that the Navajo and Bonanza plants currently have.

**Reduced Spares in the Warehouse:** The total number of spare parts required to support a new DCS system would be greatly reduced from the current number now on hand. The DCS would combine systems from several vendors into a system from a single vendor. The cost savings due to a reduced need to stock and warehouse parts has not been estimated. Currently, the warehouse has over $1.5 million dollars in spare control parts ( values as assigned in the TIMS system):

| | |
|---|---|
| Foxboro, 1/A and CCS | $629,200 |
| RIS | 140,000 |
| Bailey | 111,624 |
| GE | ~200,000 |
| Modicon | ~500,000 |
| | ~$1,580,000 |

**Reduced NOx Emissions.** One DCS vendor asserts a potential reduction in NOx emissions of up to 12 % with a new control system. The vendor estimates this would relate to a 4 % reduction in the capital cost of SCR NOx controls or over $2 million dollars. IPSC has not investigated the likelihood that a new control system at our plant would reduce NOx emissions.

## SUMMARY of DCS UPGRADE SITE VISITS

### Summary of Plant Visits to Bonanza and Navajo Power Plants
### DCS Control Upgrades

**Reason for upgrades:** Navajo and Bonanza upgraded to a new DCS because of obsolescence of old control hardware and difficulty in maintaining the equipment. Also, upgrades were done in conjunction with plant changes: new scrubbers at Navajo, and turbine and pulverizer upgrades at Bonanza.

**Systems upgraded:** Both plants have upgraded older controls to a Foxboro I/A DCS system. Bonanza did the project in four steps over 2 years: the DAS (information computer systems), scrubber controls, power block relay logic and BFP controls, and finally the turbine, burner management, and DCS controls. At Navajo, they also did their DAS systems first, then all the controls for each of three units were done, with one unit completed each year during an 8 week outage.

**Turbine controls:** Both plants replaced their dedicated turbine controls with the controls done in the Foxboro DCS. Both report this has worked well.

**Burner Management:** Both plants now do burner controls in the new DCS, replacing older dedicated systems.

**SER:** (Sequence of events recorder, or SOE) Both plants have their SER functions done in the new DCS.

**Sootblowing:** Bonanza uses sootblowing done in the new DCS. Navajo has integrated the DCS to an older PLC sootblowing system.

**PLCs vs DCS controls:** Both plants use the new DCS for power block logic (motor control of fans, pumps, etc) rather than PLCs. They also both have their scrubbers run by the DCS rather than PLCs. PLCs are still used in many areas of the plant.

**Control Board Replacement:** Both plants removed their control (BTG) boards and replaced them with an arrangement of CRTs. The big disadvantage with the computer screens noted by operators is that they couldn't see as much at once. Also, it can be slower using the screens to take action. However, comments by unit operators indicated that they liked the new controls and layout better than the old controls. Direct-wired trip buttons were available for critical equipment. Both plants had touch screens but did not recommend them or use them much, except the touch screen helps to locate the cursor on the screen quickly. Navajo used trackballs and Bonanza used mice for screen pointing.

Navajo used mostly standard graphics provided by Foxboro. At Bonanza operators built custom displays with as much information as possible on one screen. They tried to design the displays so an operator could get to where he needed to go with one mouse click. Both sites seemed pleased with what they had.

**New Control Operation:** The new controls require less operator intervention and are not operated in manual as much. The unit operators operate scrubbers from the main control room now at each plant. Normally, this requires as much time as running the units. At Navajo, the new controls are very stable, and handle runbacks very well. Ramp rate was 5 mw/min before and now 75 mw/min is possible. N0x emissions were unchanged.

**Simulator:** Navajo wanted a simulator at the time the project was beginning, but could not get approval from all participants in the plant. They now have that approval and are proceeding to procure one. Bonanza purchased a simulator from Esscor as a kit. Much of the modeling was done in-house. It was very successful for controls checkout and initial tuning.

**Support of System**: Both plants maintain and support their systems with a limited group of dedicated people. Navajo has a system administrator (a former unit operator), and I&C techs assigned to the new system. Bonanza has 2 engineers and 2 I&C techs assigned to their system. Additionally, an operator is the graphics expert. Technicians were pleased with having fewer different systems to learn since several systems have been consolidated into the DCS. Also, there are fewer different parts to warehouse. Each plant indicated a high level of expertise (training and hands-on experience) is needed to support the DCS. Also, both plants have maintenance agreements with Foxboro ranging from $140,000 to $290,000 per year.

**Project Management:** Navajo's specification and contract was done by the corporate office in Phoenix. Personnel at Page oversaw the installation and startup. Bonanza did their own specification and contract with outside help. Both sites contracted with Forney Systems to move their burner management systems to Foxboro I/A, and both used contract people during the installation for wiring.

**Comments on Foxboro:** Both sites reported Foxboro has very good hardware and they were pleased with the system and startup. Both said be wary of using Foxboro Cluster I/O. It is cheaper but will not function well in all environments. Both use UNIX for an operating system, and do no recommend using NT.

Attachment # 1 - Summary of Current System Maintenance Costs

**Attachment 1**

## Summary of Maintenance Costs for Control Systems

(costs on purchase orders, repairs, rebuilds)

| | | | | | | | Average/ year (4 yrs) |
|---|---|---|---|---|---|---|---|
| [redacted] | | | | | | | |
| [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | **41715** |
| | 1 | 1INF--0 | 83079 | 53710 | 41540 | 26855 | 34197 |
| | 2 | 2INF--0 | 22620 | 7450 | 11310 | 3725 | 7518 |
| [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | **14763** |
| | 1 | 1COA--0 | 21085 | 17134 | 10543 | 8567 | 9555 |
| | 2 | 2COA--0 | 11151 | 9680 | 5576 | 4840 | 5208 |
| [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | **3452** |
| | 1 | 1INF--B | 1116 | 8242 | 558 | 4121 | 2340 |
| | 2 | 2INF--B | 658 | 3792 | 329 | 1896 | 1113 |
| [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | **1447** |
| | 1 | 1SGH--0 | 988 | 330 | 494 | 165 | 330 |
| | 2 | 2SGH--0 | 2974 | 1494 | 1487 | 747 | 1117 |
| [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | **7886** |
| | 1 | 1TGF--0 | 11278 | 2903 | 5639 | 1452 | 3545 |
| | 2 | 2TGF--0 | 14416 | 2945 | 7208 | 1473 | 4340 |
| **TOTAL** | | | [redacted] | | | | **69261** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | **4565** |
| small part of | 1 | 1COF--0 | 3108 | 4987 | 1554 | 2494 | 2024 |
| modicons | 2 | 2COF--0 | 1017 | 1358 | 509 | 679 | 594 |
| | 9 | 9COF--0 | 2787 | 5002 | 1394 | 2501 | 1947 |
| [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | **126750** |

** Most of the Modicon costs are charged to plant equipment numbers other than COF--0. Costs are actually much higher. This happens to a smaller degree for Fox, CCS, Bailey, GE, & RIS , so their costs are higher.

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Attachment # 2 - Notes on Bonanza Plant Visit

## Fact Finding Tour
## DCS, DAS, & Simulator Replacement Project
## Bonanza Power Station

**Visit to Deseret Generation's Bonanza Power Plant: 14-Sep-00 Notes: J. Burr**

**Reason for upgrade:** Deseret upgraded because of obsolescence of control hardware. They had experieinced support problems with their Westinghouse system. They also had a goal to standardize plant controls into 2 systems. Foxboro and Allen Bradley. They used a step approach by doing their data acquisition system first, then minor systems, then the major ones together with a turbine upgrade and mill upgrade. Plant capacity is now 490 gross, up 50 mw from before.

**Systems looked at:** Honeywell, good software; Foxboro, good hardware; Westinghouse, was not responsive on info or bid (Ovation is new system)

**Systems upgraded:** The stepwise approach did have some problems, with getting data between systems. In 1998 they started and did the DAS system with 1200 points and it took 1 year. The next steps: Scrubber controls; relay logic, BFPs; BMS, DCS, turbine, in spring of 2000. Next, they will replace the electrical control board.

**Turbine controls:** These are now done in Foxboro and they work well. They do use a triconics analog card (has been a minor problem) but now a digital version is out and is better. They have had very few problems with the new controls done by Foxboro. Tim Cosca is the Fox turbine controls guy.

**SER**: (Sequence of events recorder, SOE) Replaced their RIS with Foxboro, points went from 1300 to 600 or less. ~2/3 point reduction. Now the Seq. Of Events is just a database not prints. Points come to a CP processor, but timing is an issue because Cps are not synced. Should be synced to a satellite or standard time. Print to 1/10 th of a second, but the software records to the milli second level, and this can be dumped out.

**Sootblowing:** They replaced their old system with Foxboro sootblowing done from a CRT.

**Vibration:** They replaced their Bentley-Nevada system with one from SKF. Bentley was double the money?

**PLCs vs DCS controls:** Previously power block logic was done with relays, not PLCs. The replacement choice was between the Fox DCS and Allen Bradley PLCs. The Fox DCS was chosen and this has worked well. Foxboro gateways (integrator 30s) to link to the PLCs are expensive and limited on points. By bringing the logic to the Fox controllers (CPs) they could consolidate better than using PLCs and have redundancy built in. Allen Bradley is cheaper per I/O point but the integration would have cost more, even with non-redundant gateways. From other areas in the plant they have 20 PLCs coming in on 8 Foxboro integrator 30s.

**Control Board Replacement:** They replaced the control board with a bank of CRTs. One big drawback noted by operators was that they couldn't see as much at once with the screens. Also, they felt it can be slow to go to the desired computer screen when trying to take action. Removing the board and going to CRTs is a paradigm shift that takes getting used to, but operators indicated for the most part it has been good. The new controls require less intervention and are not operated in manual as much. Also Deseret had operators design their graphic screens and most actions are only one page away. In the control room they had 7 workstation screens for Foxboro controls, and one big, large monitor, and they had a sootblowing system screen. They operate their scrubber from the main control room now.

**New Control Operation:** They have just installed their system this last spring. The plant turbine was also upgraded so many comparisons of how the old controls relate to the new are not well defined. Also, there is still tuning to be done, but they chose to run the plant this summer during the high demand for electricity and tune later. Operators and engineers said they were happy with the new controls.

**Historian:** They use the Foxboro Aim-Star historian and have 1 ½ months of data available on an optical disk. They turn the disk over for the other 1 ½ months. A hard disk would be better.

**Simulator:** Much of the modeling was done in-house with help from Esscor, by Larry Jorgensen a shift supervisor with a CS degree. The big plus of the simulator was with controls checkout and controls tuning. It was very successful. Hugh Scigliano from Foxboro used it to check out and tune the controls before loading the controls on the real system.

**Support of System**: They maintain and support the system with two engineers and two I&C techs assigned to the new system. They indicated other techs will get a chance later to work on the system. A unit operator was the graphics person and still supports that effort. Techs like only having to learn two systems now, Foxboro and AB. They felt that a smaller group of trained and dedicated people was necessary to manage the system. They have a maintenance agreement with Foxboro for ~$140,000 per year. This seems expensive.

**Project Management:** The spec was done with help of Burns and McDonnel. During the installation they used DTC (a contractor) to do wiring. They advised us to use a digital camera on the bid spec, it helps a lot. It is important to have a database including every termination. They contracted with Forney Systems to move their burner management system and baghouse logic to Foxboro I/A. In their spec, they should have had language to handle change orders and pricing better. With Foxboro there isn't really a fixed price, but one could expect to pay 30% to 40% of the list price.

**Comments of Foxboro:** Very good hardware. They are pleased with the system and startup. They recommend designing own graphics rather than using standard Foxboro graphics. They do not recommend getting the Foxboro Cluster I/O. For the DCS operating system they use UNIX not Windows NT. They have heard of problems with NT.

**Personnel:** Robert Strolle- e. engineer 435-781-5733
Mike White- e. engineer
Tom Howells- operator and graphics guy
Kreig Parker? I&C tech
Thomas Wilhem- planner and results tech ( e guide)

**Visit to Deseret Generation Bonanza Power Plant: 14-Sep-00 Notes: K. Nielson**
Attendees: James Burr, Ken Nielson, Alan Williams, & Bill Morgan

Bonanza replaced control systems by standardizing on Foxboro IA for CCS, Burner,Turbine controls and DAS; and Allen Bradley for PLCs. Previously had an array of systems including Westinghouse, Forney, Fisher, Foxboro and other. Controls replacement allow elimination of control board and reduced required operator staffing. The new systems increased information and control capabilities. 3 year phased project beginning with DAS. Simulator was installed and recommended. Recommended having simulator installed 1 year prior to controls. Bonanza pleased w/ new Foxboro IA system and Foxboro support. Further detail is provided below.

**Bonanza Site Visit Details**
The following list of questions was compiled to review during the site visit:
1. Why were the old systems replaced?
2. Was the replacement system installed in a single phase or multi-phase project?
3. How was the replacement project done?
4. Was an independent Data Acquisition System (DAS) installed?

5. Was the DAS system done at the same time as the Coordinated Control System (CCS)?
6. Did they do the controls or take old controls and transfer them?
7. How long did it take to do the new controls?
8. Who configured the process graphics and operator interfaces?
9. Was a simulator installed?
10. Where in the project chronology was it installed?
11. How was the simulator done?
12. How were operators and system users trained?
13. With operators trained, how much continuing training is done?
14. Is the simulator used to test 'what if' scenarios for the CCS?
15. Were control rooms modified with the new CCS? If so, how?
16. How is support staffing structured for the new DCS, DAS, and Simulator systems?
17. How were support personnel trained?
18. Which/What replacement system(s) were selected? Why?
19. How successful and accepted has the replacement system been?
20. How was replacement project support from the system vendor?
21. How has post installation support been?
22. Does the vendor offer continuing modernization/upgrade support plans?
23. Are these used?
24. What are the details of such this plan?
25. What would be done differently?

Discussions on the replacement project and recorded notes are organized below according to the pre-compiled question list shown above.

1. What were the previous control systems?
   a. Previous to the current systems, Bonanza had Westinghouse controls, Forney burner controls, and an array of control systems and PLCs.

2. Why were the old systems replaced?
   a. Replaced old systems due to support problems from Westinghouse and due to system obsolescence.
   b. In some cases, they had been notified that support for particular components would be dropped within 1 to 2 years.

3. Was the replacement system installed in a single phase or multi-phase project?
   a. New systems part of a multi-year project that began in 1998. Started with the DAS first, then as much of the controls on-line as possible, then the CCS, Turbine, and Burner control systems.
   b. In 1998 the DAS system was installed. Approximately 1200 points in the DAS.
   c. Replaced the scrubber controls about 6 months later followed by the relay logic. Much of this was done on-line.
   d. Replaced the CCS in the spring of 2000. An outage was required for this segment of the replacement project. It was also done concurrently with the replacement of the turbine rotor and some of their pulverizers.
   e. There is a lower outright cost to do all controls at the same time due to the amount of data links required to old systems. But, the phased approach allowed operators time on the IA DAS system while allowing them to use the old familiar controls.

4. How was the replacement project done?
   a. Contracted with AE was done to prepare as specification for the procurement process. However, a modified version prepared by Bonanza technical staff that was more useable and is the basis for the project documents.

b. Specified that replacement systems would be standardized. Though installed in phases, proposals were for all segments of the replacement systems.
c. Project management done by engineering at Bonanza.
d. Much of the system configuration done by DG&T personnel.
e. Simulator development done by in-house support at Bonanza. See more information below.
f. Contractors used in I/O replacement.
g. Controls and system configuration done by Bonanza staff, Foxboro, and Foxboro subcontractors.
h. Graphics built by operations personnel.

5. Was an independent Data Acquisition System (DAS) installed?
   a. The DCS and DAS system are integrated and considered part of the same system. They are separate components of the IA system at Bonanza.
   b. Currently, use I/A for DAS. Use AimStar historian by Foxboro. Started with FoxHistory, but found that system to be unreliable. That was replaced by the Aimstar system.
   c. Likely to go to an off-platform systems in the future to provide desktop access to data.
   d. PC/Desktop access is available to a limited amount of on-site users. PC/Desktop access is available through connection to an AW (applications workstation) to authorized users only.

6. Was the DAS system done at the same time as the Coordinated Control System (CCS)?
   a. No. Though considered now to be different components of the same system, the DAS segment of the system was installed about 2 years prior to the CCS systems.

7. Did they do the controls or take old controls and transfer them?
   a. Rebuilt from the ground up by Foxboro.
   b. Controls were test and pre-tuned on the simulator.
   c. Old terminal blocks were used where possible, but most I/O terminal blocks from previous systems were replaced.

8. How long did it take to do the new controls?
   a. Done by Foxboro (thought to have taken about 1 year.).
   b. Tuning included dumping the controls to the simulator. Then, made changes on the DCS according to what they had done and tested on the simulator. They did not dump the controls back to the DCS.
   c. The tuning was sufficient to allow successful start-up and operation to meet production demands. However, additional tuning will be completed on the on-line system during their fall outage.

9. Who configured the process graphics and operator interfaces?
   a. Operators built and largely support modifications to the DAS graphics. This was very successful and recommended. Minimally, there should be operator involvement in the graphics display creation.
   b. Some graphics simulate old manual controls with added trends and color status indicators.
   c. They do not like the touch screens. While sometimes convenient, they are costly to maintain and reliability is not as high as they would like.
   d. One operator is assigned and acts as the controller up implementing changes and enhancements.
   e. Estimated that 1.5 to 2 man-years were required to build the graphics.

10. Was a simulator installed?
    a. Yes, a Simulator by Esscor.

11. Where in the project chronology was it installed?
    a. Implemented between the DAS and CCS replacement systems.

12. How was the simulator done?
    a. Esscor simulator. The basic simulator 'kit' was received from Esscor and the simulator system was built by Bonanza personnel.
    b. Received simulator for operator training just prior the spring 2000 outage. This was insufficient to allow adequate training time for operations personnel on controls.
    c. Simulator was used for pre-startup tuning. The pre-tuning effort was very successful.

13. How were operators and system users trained?
    a. Operators had one (1) to two (2) years experience with the DAS part of the IA system and the scrubber controls.
    b. They recommended that the DAS be installed a year or two in advance to allow familiarization w/ Foxboro IA before use for start-up and unit control.
    c. Only a month or two of simulator training was available for simulator training prior to restarting the unit.
    d. There were no trips due to operator error. Had one trip due to the failure of an IA system CP (control processor) failure.

14. With operators trained, how much continuing training is done?
    a. So far, work is continuing on the simulator by systems personnel as time permits.
    b. Little additional training has been done. However, operations an engineering personnel would like to see much greater user of the simulator for training.

15. Is the simulator used to test 'what if' scenarios for the CCS?
    a. Not currently, but intend to do so.

16. Were control rooms modified with the new CCS? If so, how?
    a. Yes, manual control boards were replaced with CRTs. Pre-installation of the DAS allowed familiarization w/CRT before manual systems are removed. Plus new controls are good enough to largely eliminate the need for manual interaction for most situations.
    b. Replaced the manual control panels in three (3) phases from 1998-2000. Phased out the control panels. Replaced with a quantity of twelve (12) 21" CRTs and one (1) 46" CRT. The new CRTs are arranged in blocks of four (4) CRTs. Each block of CRTs is separated from the next by a console with hard-wired trip/start buttons and small video screens showing some site locations. The large CRT is ceiling suspended and used for primary trends.
    c. The new CCS eliminated the need to control from the scrubber control room and put those controls in the main control room. However, an AP (application processor) has been located in the scrubber control room to allow control from that location in case there is a communications failure to the main control room.
    d. With the elimination of the control panel, the Rochester sequence of event recorder (SER) and annunciator light boxes annunciation system was eliminated. All annunciation is done from the IA system.
    e. Initially, there was considerable apprehension among operations personnel about this modification. Operations personnel indicated that once they were familiar with the new systems, they have come to prefer them.
    f. With a manual control board, multiple control switches could be activated somewhat simultaneously. With CRTs, good organization and management of control screens has been required to duplicate that capability. However, with the CRT controls, much more operating information is available. Again, display/screen organization and management is critical.
    g. DG&T operations and technical staff were unanimous in recommending that custom screens be developed in-house rather than use the standard Foxboro built screens.

17. How is support and support staffing structured for the new DCS, DAS, and Simulator systems?
    a. Have a support agreement with the TAC (Technical Assistance Center) at Foxboro. Also the utilize the FoxWatch capability that allows a secured remote login access (call back security) to authorized Foxboro support personnel. The contract cost is currently about $140,000/year. Bonanza technical staff seemed very please with this agreement and the support and results that it has yielded. Comments included that Foxboro had provided good response via this program. Without the contract, they found their support calls to be addressed on a lesser priority.
    b. Staffing includes:
        i. Two (2) systems engineers
        ii. Two (2) Dedicated I&C techs for support, backups, etc...
    c. All techs are trained to use and support the system. The ideal plan is to rotate all through the system eventually. However, they largely allow personnel to focus on areas where interests and expertise best serve the company. This seems to have fostered more ownership in care for the job and systems.
    d. Controls changes are initiated by any of the primary four (4) support or engineering personnel. Then prior to implementation on the live side, a review by at least one (1) of the other primary personnel is required.
    e. Technicians are on call on weekends.
    f. With the standardization of equipment, a great deal of the problems with rotation and getting people up to speed on equipment has been eliminated.

18. How were support personnel trained?
    a. Primary systems personnel pre-trained for system installation support.
    b. Other I&C support personnel and system users trained via on-site training class.

19. Which/What replacement system(s) were selected? Why?
    a. Bonanza standardized on Foxboro for controls and Allen Bradley for PLCs. Have found Foxboro easy to use and support.
    b. They use Foxboro for turbine controls and used Foxboro to replace the Forney burner control system, but Forney did the engineering on that portion of the system.
    c. I/O terminal blocks for the Foxboro systems were found to be superior to competitors due to size. Competitors were cited for having large terminal block while the Foxboro system use compact TB sections.
    d. Used MK Engineering system for CEM.
    e. Deseret has employed the automatic soot blowing system from Foxboro.
    f. Though Westinghouse probably had the best opportunity for winning the replacement system, they did not get the bid because they were unresponsive to the bid process, worst prepared in their proposal, and not competitive in cost.
    g. NT v. Unix: Bonanza went with Unix. Found it to be more solid to upgrade and easier to use with the application. Foxboro had had some problems with their NT versions. Bonanza has had one controls related trip. This was due to the failure of a Foxboro Control Processor (CP).

20. Were any PLCs replaced with DCS systems or DCS with PLCs?
    a. Did not use Foxboro to replace any PLCs. Did use Foxboro to replace some relay logic that should have been put on a PLC.
    b. More notes from DG&T on PLC vs. DCS control.
        i. If control can be done on a PLC and the data is not needed on the DCS, then that is cheapest and most efficient (from the system loading perspective) method to follow.
        ii. If the data is needed on the DCS then a gateway will be needed between the DCS system and PLC. There is a data capacity limit on gateways. The cost of PLC to gateway to

DCS configuration is about equal with the DCS to DCS control module. As such elimination of the PLC and control directly with the DCS control module is a viable option.

iii. Control by the DCS with a pass through to the PLC to the process is not recommended. That configuration introduces an additional 2 points of failure plus the loading/system speed impact of the gateway.

21. How successful and accepted has the replacement system been?
    a. System has been reliable. Only one trip attributable to controls. This was due to the failure of a CP hardware module and not a failure due to controls malfunction.

22. How was replacement project support from the system vendor?
    a. Excellent.

23. How has post installation support been?
    a. Excellent.
    b. Support contract and Foxwatch support has been very responsive and is recommended.

24. Does the vendor offer continuing modernization/upgrade support plans? If so, are these used?
    a. A support contract is in place with Foxboro.
    b. Contract does not include gradual modernization of new systems.
    c. Possible option for such available from Foxboro.

25. What are the details of such this plan?
    a. No information at this time.

26. What recommendations for a new project of this type?
    a. Ensure the at least 10-15% spare i/o capacity is built purchased with the new system. Recommended at least on spare slot per i/o TB pack.
    b. Write in pre-agreed methods and costs for escalation of support and installation assistance should such escalation be required.
    c. On change orders or needs for additional material, write in pricing restrictions or guarantees for the purchase of additional or future equipment. 30-40% off of list is not an unusual discount.
    d. Ensure that the vendor will supply functional, logic and detailed schematic layout drawings of the new systems and controls. Foxboro provided basic logic drawings. But AE worked with Foxboro on some controls and provided much more useable and workable detailed schematics and functional diagrams.
    e. Ensure that software upgrades during the project implementation time are included and automatic during the project implementation. This will prevent having to purchase software upgrades for previously installed systems when implementing the later phases of the project.
    f. Also, a means for routine upgrades may be built into maintenance support agreements.
    g. Used a database similar to our Fox 1/A database to build and pre-configure the point databases for the new system. This was especially useful to contractors doing the wiring changes from the Westinghouse or other terminal blocks to the Foxboro TBs.
    h. Install simulator earlier that happened with their schedule.

<u>SUMMARY</u>

The visit to the Bonanza power station was very informative. It provided an opportunity to see the results of a controls and data acquisition system replacement project. The Bonanza DCS/DAS replacement project was pursued in a phased approach. It included the replacement of the I/O capability of the old systems and the installation of a simulator for training and pre-startup tuning.

Phase 1 installed the DAS system. Phase 2 brought the installation of DCS capability for areas that would allow on-line installation. Phase 3 installed the primary CCS, turbine, and burner control systems. That phase required a unit outage and was planned to coincide with a major unit outage in which the turbine rotor and some unit pulverizers were replaced.

The project was initiated due to obsolescence and lack of capacity in the previous systems. Foxboro was selected and the replacement for DCS systems. Allen Bradley was selected as the replacement for PLC systems. Previous systems included: Westinghouse, Forney, Fisher, Foxboro and others.

The DCS replacement project allowed replacement manual switch control boards. Control room monitoring capability included primarily CRT based operator interface. Monitoring of processes from remote or back-end control rooms was relocated to the main unit control room. This resulted in a reduced requirement for operator staffing. Operations personnel indicated that the use of CRTs for control and elimination of the manual control boards was a significant change, but was successful and now largely preferred. Old control boards allowed the actuation of multiple switches somewhat simultaneously while CRT commands could only be done one operation at a time from a single screen. The use and availability of multiple CRTs largely compensated for that advantage. And, as display design and CRT usage patterns improved with experience, operations staff indicated that they expected the CRT system to be fully superior to the manual control panels. They further indicated that the added responsibility of monitoring back-end and outer area operation from the main control room had not impeded their ability or quality of control. They attributed this to the improved control capabilities of the new DCS systems and increase in available data to the operator through the new systems.

The new systems increased both information and control capabilities. Both technical and operations personnel indicated that installation of the DAS prior to the DCS allowed valuable on the job pre-training in the use of the IA systems prior to controls replacement.

Operations personnel were utilized for the majority of controls and information displays construction (See attached examples.). Both operations and technical personnel indicated that this was a very successful and recommended method. A unit operator was designated as the primary authority for screen changes and construction. Modifications to controls and information screens were coordinated through or completed by that operator. Operators indicated that display design varied significantly from standard Foxboro displays. A primary goal of the Bonanza screens was to get anywhere needed with one mouse click. Touch screens were installed, but operators preferred the mouse and keyboard interface.

The simulator was purchased from Esscor which is a sibling company to Fxoboro under Invensys. Bonanza chose to purchase and Esscor "kit" simulator and build the simulator system internally. The simulator was completed about 1 to 2 months prior to the major unit outage wherein the primary controls systems would be replaced. It was used successfully for pre-tuning the new controls. Bonanza personnel recommended having the simulator completed about 1 year prior to controls to allow for more operator training and better development of tuning.

The new DCS and DAS systems at Bonanza are considered different components of the same system. Systems modification projects and overall engineering responsibilities are handled by systems and controls engineers. System maintenance responsibilities are handled by I&C personnel. With IA installed plant-wide as the DCS standard, new and continued training requirements for I&C personnel has been streamlined. All I&C personnel were trained on IA and Allen Bradley. However, specific I&C personnel are assigned to specific areas of responsibility. Since all equipment is the same, technicians with one area of responsibility can support most repair in other areas. Support for complex after-hours or weekend problems in areas outside of the shift I&C personnel's primary area of responsibility could be escalated by means of "on call" support by engineering or I&C personnel primary to a given system. Bonanza personnel indicated that allowing technicians to migrate to specific areas per interest and expertise had resulted in greater ownership in their jobs and areas of responsibility.

They would like to eventually rotated everyone through the DCS support. But, there are no plans to do this in the short term future.

Changes to the on-line systems are completed by either the engineers or technicians assigned with primary support for a given system. Typically, there will be one (1) or two (2) engineers and two (2) technicians with primary authority for any given area. Changes on a system could not be implemented without review of one (1) or more of this primary support group for a system. Once a change has been made, procedures include providing notification and updated documentation for the change to other engineering and I&C personnel.

Bonanza personnel were pleased with the new Foxboro IA systems and with Foxboro support. They indicated that both installation project support and post installation support have been very satisfactory.

Attachment # 3 - Notes on Navajo Plant Visit

# Fact Finding Tour
# DCS & DAS Replacement Project
# Salt River Project - Navajo Generating Station

**Visit to SRP's Navajo Power Plant: 27-Sep-00 Notes: J. Burr**

**Reason for upgrade:** Navajo upgraded because of obsolescence of old hardware, and installation of new scrubbers. Previously they had an old Bailey 820 analog control system with GE Turbine controls. They had a turnkey contract with Foxboro that covered installation of equipment over 3 years starting in 1997. First they replaced their DAS (information system). They upgraded 3 units. The first was done in 1997, the second in 1998, and the last in 1999. Each was done in under 8 weeks during an outage.

**Systems they looked at:** The corporate office did the spec, vendor selection, and contract. Foxboro was chosen, but Honeywell, Bailey, and Westinghouse were considered. The control system at SRP's Coronado Plant was replaced with Honeywell shortly before Navajo's project. It was reported things haven't worked out as well (with Honeywell) as with Foxboro. SRP has since used Foxboro on several other plant upgrades.

**Systems upgraded:** In 1997 they began with DAS systems. (Previously, they had an old Honeywell information systems). This required a new link to their old controls, which became unnecessary after controls and DAS were all Foxboro I/A and there were 500 points not needed. The cost was ~$16 million for unit and scrubber controls for 3 units. What was in 16 Bailey cabinets is now in 3 Foxboro cabinets. After the DAS, the Scrubber controls, BMS, DCS, turbine, SER and annunciator done all at once.

**Turbine controls:** These are now done in Foxboro and they work well. They have had very few problems with the new controls done by Foxboro. The controls for the BFP turbines are done with Woodward and interface with Foxboro. They said Woodward's support isn't so great and would like to replace the controls with Foxboro I/A.

**SER**: (Sequence of events recorder, or SOE) Replaced with Foxboro. They use the "causes of trips" only and have 50-100 points. Other items are alarms. They have a 3rd party package (Logmate) to determine sequence on a CRT.

**Sootblowing:** This is done with previously existing Allen Bradley PLC 5. It is integrated to the Foxboro and use Fox graphics for operation. Operators decide what sootblowing is done, it is not automatic.

**O2 Measurement System**: They have a Thermox AMTEK system and are happy with it.

**PLCs vs DCS controls:** They have power block logic for motor control of fans, pumps, etc done with Foxboro controls rather than PLCs. They recommend this in the main area of the plant. It is a more reliable way to do the control. They also use Foxboro in their scrubber controls rather than PLCs.

**Control Board Replacement:** They removed their control board (BTG) and replaced it with an arrangement of CRTs. The big disadvantage noted by operators was that they couldn't see as much at once with the screens. But overall the unit operators indicated that they liked the new controls and layout better. In the control room they had 5 workstations with 2 screens each for the main plant controls. They also 4 other screens for Alarms, plant LAN, and 2 scrubber/back end screens. There are direct-wired trip buttons for critical equipment. They have touch screens but do not recommend them or use them much, except the touch screens help to locate the cursor on the screen quickly. They would like the cursor to be more visible. Also the desk part of the station in front of the CRTs and keyboard should be larger for writing. Operators felt like the CRT stations should be in more of a U shape to help view things quicker. They used trackballs and were pleased with them.

Termination cabinets were installed in place of the BTG control board to handle wiring that had come directly to the board. Operators used a basic-generic simulator for training from Esscor but they were not pleased with the usefulness of this. The Foxboro controls guy, John Benoyer came and did a 2 week school for the operators. Initially only one unit was on the new control system, followed by another unit each year. Most of the operators preferred to work on the with the new controls once they became familiar with them.

**New Control Operation:** The new controls require little intervention and are not operated in manual as much. The unit operators operate the scrubbers from the main control room now, and normally requires as much time as running the units. The new controls are very stable, and handle runbacks very well. Ramp rate was 5 mw/min before and now do 75 mw/min is possible.

**More on software:** Foxboro provided a program for operators called "Operator Watch". Also they had an annunciator software program from Foxboro called "WASP". When a big upset in the unit occurs, up to 200 alarms may come in. Smart alarming is available but has not been configured. This should have been done up-front. Foxboro also provided a starting and loading program for unit startups. For maintenance issues, Foxboro has a preventative maintenance package which includes equipment runtimes.

**Graphics:** Graphics were built in Foxboro's "Display Manager" product, Foxboro now has a new product out called "Foxview". They used Foxboro's standard screen layouts for controls, which allow up to 8 control face plates on a page in combination with trends of other items in any of the 8 locations. They use face plate pages during normal operation, but use lots of process graphics during startups/shutdowns. The graphics were built mainly by operators.

**Historian:** They use the Foxboro legacy historian (not Aim-Star) for the control room but have an additional package called RTX (similar to PI) for engineers and managers to access plant data.

**Simulator:** The plant wanted a simulator from Esscor at the time the project was beginning, but could not get approval from all participants in the plant. They now have that approval and are proceeding to procure one. They indicated, a simulator would have been a big benefit prior to the installation and startup of the controls.

**System layout**: They have 3 processors dedicated to the DAS (information) and 11 control processors all of which are redundant. The make have a rule not to control with DAS points, so they only use control points.

**Support of System**: They maintain and support the system with a small group of dedicated people, none of which were engineers. The engineers they currently have at the plant don't work much on the controls. The people working on the system volunteered to for the project before it began. They have a system administrator (a former unit operator) who was a former unit operator, and 2 or 3 I&C techs dedicated to the new system. An additional tech was just reassigned to another plant. These people are still hourly and they maintain the system out to the field wiring. There have been some problems lately with technicians who are not working on this system feeling they are missing out. The system technicians we talked to, indicated that a high level of expertise ( training and hands-on experience) is required to support the system. They said this takes years, not weeks, to acquire. Hardware failures are very rare after startup, and when techs are called out, the problem is usually due to field problems. Control system changes are done rather informally. Changes are discussed with technicians, operators, results people, and engineers, then implemented.

**Project Management:** The spec and contract was done by the corporate office in Phoenix. Personnel at Page oversaw the installation and startup. Early in the project, engineers from the corporate office inventoried all control and wiring cabinets including everything in the control panels. During the installation contract people were used for wiring.. They contracted with Forney Systems to move their burner management system to Foxboro I/A. They specified to Foxboro, that Fox engineer John Benoyer to do the controls configuration. This was because they were familiar with him and he is one of the best. They indicated much of the success of the controls depends on the person that does them. The scrubber controls were done by the contractor for the scrubber (using Foxboro I/A) and they are less pleased with them. They have a full service maintenance agreement with Foxboro for ~$240,000 per year.

**Comments on Foxboro:** Very good hardware. They are pleased with the system and startup. Unlike Bonanza, they mostly used standard Foxboro graphics for control, configured to their needs. They have some Foxboro Cluster I/O for some cabinets. It is cheaper but will not function in hot environments. Also, they have had problems with connectors coming loose. They use UNIX for an operating system , and do no recommend using NT.

**Personnel:** Bob Swapp, system administrator, former unit operator
Willie Barber I&C tech
Jim Mace I&C tech

**<u>Visit to SRP's Navajo Power Plant: 27-Sep-00 Notes: K. Nielson</u>**
IPSC Attendees: James Burr, Ken Nielson, Alan Williams, & Bill Morgan

Navajo replaced DCS and DAS systems with Foxboro IA, Allen-Bradley is the PLC standard, and RTX is the off-platform plant historian. Retained Woodward for BFPT controls, but trying to migrate to Foxboro. CCS replacement precipitated by scrubber project. Previously, had Bailey controls w/Forney burner management system. New DCS allowed elimination of unit control boards, reduced required operator staffing, and increased DAS/DCS capability. 3 year project done by unit w/DAS & DCS replaced at same time. Simulator not purchased initially, though now approved for installation. Strongly recommended installation of Simulator prior to the DCS. Navajo was pleased w/ new Foxboro IA systems and support. Further detail is available below.

**<u>Navajo Site Visit Details</u>**
The following list of questions was compiled to review during the site visit:

1. Why were the old systems replaced?
2. Was the replacement system installed in a single phase or multi-phase project?
3. How was the replacement project done?
4. Was an independent Data Acquisition System (DAS) installed?
5. Was the DAS system done at the same time as the Coordinated Control System (CCS)?
6. Did they do the controls or take old controls and transfer them?
7. How long did it take to do the new controls?
8. Who configured the process graphics and operator interfaces?
9. Was a simulator installed?
10. Where in the project chronology was it installed?
11. How was the simulator done?
12. How were operators and system users trained?
13. With operators trained, how much continuing training is done?
14. Is the simulator used to test 'what if' scenarios for the CCS?
15. Were control rooms modified with the new CCS? If so, how?
16. How is support staffing structured for the new DCS, DAS, and Simulator systems?
17. How were support personnel trained?
18. Which/What replacement system(s) were selected? Why?
19. How successful and accepted has the replacement system been?
20. How was replacement project support from the system vendor?
21. How has post installation support been?
22. Does the vendor offer continuing modernization/upgrade support plans?
23. Are these used?

24. What are the details of such this plan?
25. What would be done differently?

Discussions on the replacement project and recorded notes are organized below according to the pre-compiled question list shown above.

1. Why were the old systems replaced?
   a. Obsolete control systems and the scrubber installation project precipitated the replacement of their control systems.
   b. Navajo had obsolete Bailey controls on their units. Unit control panels were all manual which limited the availability of this information.

2. Was the replacement system installed in a single phase or multi-phase project?
   a. Multi-year project with installation synchronized with the installation of the scrubbers beginning in 1997 and ending in 1999.
   b. DAS and DCS systems on a given unit were replaced at the same time during outages to implement the newly installed scrubber systems.

3. How was the replacement project done?
   a. Replacement was synchronized with the outages required for scrubber implementation.
   b. Did project one unit per year over three years. Each unit was done within an eight (8) week outage.
   c. Went from Bailey to Foxboro IA. I/O for the control systems was also changed to IA nodebus technology.
   d. On BFPT controls, Navajo is moving from MAC to Woodward, but would like to migrate all controls to Foxboro.
   e. Sootblowers are allen Bradley (Coal Slocum?). IA is connected through an integrator. Sootblowers starts are not automatically initiated, but rather initiated by Operator action.
   f. Replaced 16 Bailey cabinets with 3 Foxboro cabinets.
   g. Foxoboro IA 51B systems were installed.

4. Was an independent Data Acquisition System (DAS) installed?
   a. Yes and No.
   b. Each unit has a separate IA system. Though part of the same IA system, there are dedicated DAS and DCS components.
   c. During installation, the DAS portion of the system was installed first, then the DCS. Since the DAS and DCS systems started separate but are now essentially part of the same system, a rule of thumb is applied that controls are only done on and from controls points/components and data functions are loaded only on the DAS components/points.
   d. Prior to the IA system, no sequence of events recorder was available except for light box windows. This was all replaced by Foxboro IA. This system replaced a 775 point annunciator plus an additional 700 points.
   e. Foxboro has a package called WASP (Window Annunciation Software Package) which is the virtual creation of light box windows on a CRT. Users can click on a virtual light box for information on that point. Navajo has the WASP system; but instead of the WASP, they use a plant overview display with a blinking equipment primitives to indicate troubled equipment or conditions. They find this to work better than the annunciation windows or simulated windows.
   f. The sequence of events capability in IA is millisecond. But they indicated taht care needed to be taken that the SOE is not configured faster than the actual point updates.
   g. Navajo has 52 points configured for SOE. These are points for parameters or equipment that will cause a unit trip. Everything else recorded in the regular IA system for determining what happened after a trip and in what order.

h. DAS is a rolling historian. Navajo uses the "legacy" IA historian.
i. RTX is their long-term, "off-platform" archive system with 2 second resolution. Mostly provides process trends and includes an Excel interface. RTX is a company that was built by former Foxboro persons.
j. All RTX servers are located in the unit control building in a computer room back of the unit control room.
k. They have other Foxboro software or applications packages for preventative maintenance and run-time totalization, reports, etc.
l. Will be replacing their alarm printers with PCs using "Logmate" software.
m. Fiber optic links connected the scrubber and unit IA nodes.
n. Inter-unit connection is available to authorized personnel on the IA system although this option is used only when necessary. Navajo implemented a rule of thumb that controls changes to be done for a specific unit should be done on and from IA application workstations on that unit even though interconnection to APs from other units was possible.

5. Was the DAS system done at the same time as the Coordinated Control System (CCS)?
   a. Yes, the DAS was replaced during the same outage as the DCS on a given unit. However, during the outage, the DAS was installed first, then the CCS. A second DAS system was installed during a later 2 week outage.
   b. Problems with going with the DAS first is the need for intermediate links to the old system that will then be discarded when the balance of the old equipment is replaced.

6. Did they do the controls or take old controls and transfer them?
   a. John Benoyer (Venoyer) of Foxboro did their unit controls.
   b. Scrubber controls were done by SWE and ABB who received the hardware from Foxboro and did the controls themselves.
   c. On controls, Foxboro used a model from Texas Utilities for basic controls model. Then the controls were adapted to the specifics of the Navajo units.
   d. Burner management was done on IA by Forney. Forney just took what was in the old system and rebuilt those burner controls in the IA system.
   e. Philosophy generally followed by Navajo is that no equipment is started automatically. This is primarily for safety.
   f. IA has a good modicon interface, but there is some slow down in the scan rate with any interface and each interface to another system requires an "integrator" device (or gateway which introduces not only the slow down, but an additional point of failure.
   g. Troubleshooting all done in software on IA

7. How long did it take to do the new controls?
   a. Installation was done during an eight (8) week outage. However, a significant amount of pre-configuration of controls was completed by Foxboro.
   b. Installed and initially tuned during unit outages for installation of the new scrubbers.

8. Who configured the process graphics and operator interfaces?
   a. Navajo personnel built own displays on the DAS system using Foxboro face-plates for control.
   b. Display Manager by Foxboro was used. Foxboro now has the FoxView package which has a greater capability for customization.
   c. Displays were largely built by an operator on the installation group. That individual remained in the IA support group.

9. Was a simulator installed?
   a. No and Yes. No simulator was installed prior to installation of the DCS/DAS systems.

However, Navajo has just recently approved a simulator.

b. Navajo personnel indicated that it would have been much better to have before startup.

10. Where in the project chronology was it installed?
    a. Approved for purchase in the coming year.

11. How was the simulator done?
    a. N/A

12. How were operators and system users trained?
    a. Initial startup was done by the systems team.
    b. Regular operators trained on the job during the start ups wby working in conjunction with the installation/systems team.

13. With operators trained, how much continuing training is done?
    a. Thought that the use of the simulator would have prevented some unit trips and will help avoid trips in the future. Need to have operator s familiar/2nd nature on using the new DCS systems. The new systems handle most conditions in auto mode quite well. Lack of training caused some operators to take action during events when none was required. Continued training with the simulator was thought to help operators from over-reaction during process events.
    b. Navajo systems personnel indicated that the simulator was necessary to keep people sharp. With the new control systems, problems and start-ups are much fewer and further between.

14. Is the simulator used to test 'what if' scenarios for the CCS?
    a. As yet, N/A.

15. Were control rooms modified with the new CCS? If so, how?
    a. All manual board components and the entire manual control panel previously in use at Navajo was replaced by the IA CRT command station.
    b. Arrangement of CRTs included 14 CRTs in a bent or slightly curving formation. Six (6) CRTs were vertically, double-stacked in the center of the command station with an additional pair of CRTs vertically stacked on each flank. Each pair of these CRTs were supported by an IA workstation processor (WP). These ten (10) CRTs were dedicated to unit control and monitoring. On one end of the command station, an additional four (4) CRTs were mounted horizontally at eye level. The first two (2) were IA CRTs supported by one (1) WP. These were dedicated to scrubber control. The next CRT was PC connected providing access to the plant LAN and maintenance management system. The final CRT was for an IA application processor. An additional two CRT sized panels with hardwired buttons for operator action were located in the operator command station. These included hardwired unit and turbine trip buttons. Trackball and mylar keyboards were provided for each system pair of WP CRTs. Two (2) alarm printers and a tagging PC were place adjacent to the command station and available for unit operator use.
    c. As the DCS was replaced and operators came up to speed, the operators have preferred the new IA systems to the control panel.
    d. Application and workstation processors were UNIX workstations.
    e. Though used initially after the scrubbers came on-line, scrubber control rooms are no longer used.
    f. Each unit operator handles a portion of the outside area controls. There are three units; hence, three UOs with a control command station as descibed above per unit. Each UO has one or two auxiliary operators available assist as required.

16. How is support staffing structured for the new DCS, DAS, and Simulator systems?
    a. Met with the three (3) systems personnel: Bob Swapp, Jim Mace, and William Barber.
    b. Two (2) came from I&C and one (1) from Operations. The individual from Ops. did the graphics, then was assigned system administration. The two (2) technicians from I&C technicians worked with Foxboro on the controls and now are responsible for controls changes and maintenance. They are no longer part of I&C or Operations.
    c. They had four (4) systems people initially, but one has since transferred SRP central office in Phoenix.
    d. They strongly recommended a closed system support group due to the learning curve involved with the systems. They handle support issues and controls changes.
    e. Then they turn problems that deal with the field devices to I&C for action.
    f. When questioned about support depth and after-hours support, they indicated that as yet there had been no problems. Some after hours support issues were handled on a call-out basis.

17. How were support personnel trained?
    a. All systems personnel were fully trained at Foxboro. The two I&C systems technicians do all controls modifications.

18. Which/What replacement system(s) were selected? Why?
    a. New system are all Foxboro IA for CCS, turbine, and burner controls. This has been a benefit as replacement parts are homogeneous.
    b. Honeywell, Bailey, Westinghouse, and Foxboro were all bid competitors on the project. Foxboro won with low bid.
    c. Unix is recommended over NT for the control system operating system. Their opinion was that UNIX was more secure and stable for this type of application.
    d. Allen Bradley is their PLC plant standard (Model 540)
    e. Navajo uses Tri-Sen controllers for the turbine valve servos.
    f. All plants with the Salt River Project are upgrading their coordinated control systems. The first was Coronado that went with Honeywell. That system, while successful in meeting project goals, has been less than satisfactory in overall performance in comparison for Foxboro which has been the selected standard for other SRP plants.

19. How successful and accepted has the replacement system been?
    a. The new DCS didn't effect NOx output.
    b. Improved ramp rate form 5 MW/min to a typical capability of 50 MW/min and a maximum capability of 75 MW/min.
    c. While initially uncomfortable with the CRT based control panel, all operators indicated that they now thought they were better than the panels they replaced. Different techniques and methods of information and controls management was required by the operators in using the CRT base systems.

20. How was replacement project support from the system vendor?
    a. Foxboro support has been great. Excellent system engineering, installation support, and hardware support.
    b. Used Foxboro for replacement of I/O wiring. This turned-out very well.
    c. Navajo indicated the greatest level of satisfaction in the segments of the project completed in which Foxboro was the primary contractor.

21. How has post installation support been?
    a. Reported very satisfied with Foxboro support.

b. They have a "Foxwatch" support contract.
c. Support cost per year with Foxboro is +$240,000.

22. Does the vendor offer continuing modernization/upgrade support plans?
    a. Navajo not utilizing this type of service from Foxboro. However, they recommended that such upgrades during the installation phases might be addressed in the specification to ensure all components and/or software up to date at the conclusion of the installation project.

23. Are these used?
    a. At present they are not using such as service from Foxboro.

24. What are the details of such this plan?
    a. N/A

25. What would be done differently?
    a. Cluster I/O has mixed review. Some problems w/ connectors staying attached and with bad I/O indication to the DCS. Cluster I/O in a bigger qty of I/O for a given space. If they were to do it over, they would use FBMs instead of cluster. Each card handles 64 digital or 16 ananlog inputs. It is somewhat cheaper. Cluster I/O cards are very heat intolerant.
    b. Operators at Navajo did not like the touch screens very well. Absolutely not used for start and stops on equipment or changes on set points. OK to use to find cursor and to change screen displays.

SUMMARY

The visit to the Navajo power station was very beneficial. Navajo had selected the Foxboro IA system for the replacement DCS system. This allowed IPSC personnel to focus on project issues, sequence, and technology transition issues rather than comparisons of different DCS vendor products. This was consistent with the intent of the visit.

The Navajo plant visit provided the perspective of a replacement project for the DCS and data acquisition systems in a larger plant/unit environment. While done over a multi-year project, DCS and DAS systems for a given unit were replaced during the same outage. This contrasted with the phase installation approach applied at Bonanza.

The Navajo DCS/DAS replacement project began in 1997 and was completed in 1999. It included the replacement of the I/O capability of the old systems. It also included the installation of DCS systems in the newly installed scrubber systems. These systems were also IA systems. A simulator was not installed prior to the DCS/DAS systems. One had been planned but installation was delayed by project participants. A simulator is currently approved for purchase and installation. It will be used to provide continued training for operations personnel and for testing of tuning and controls changes. Navajo personnel indicated that continued operator training with the simulator was considered essential as the new DCS systems minimized trips and unit events and accordingly minimized exposure to unit start-ups and event reaction training.

The DCS/DAS replacement project was initiated due to obsolescence and lack of capacity in the previous systems. These factors along with the project to install scrubbers on the Navajo units precipitated the installation/replacement of the DCS systems. Foxboro was selected as the replacement for the boiler, turbine and burner control systems. The previous systems included Bailey and Forney. Allen Bradley is their PLC plant standard (Model 540). Navajo uses Tri-Sen controllers for the turbine valve servos. BFPT controls are being moved from MAC to Woodward, but they would like to migrate all controls to Foxboro. Sootblowers are Allen Bradley (Coal/Cole Slocum?). IA is connected through an integrator. Sootblowers starts are not automatically initiated, but rather initiated by Operator action. Navajo systems personnel indicated that the replacement of the previous systems with Foxboro systems had streamlined spare parts and support issues.

The DCS replacement project also caused replacement of the manual-switch control boards. Control room monitoring capability now includes a CRT based control panel for operator interface. Operations personnel indicated that the use of CRTs for control and elimination of the manual control boards was a significant change, but was successful and now largely preferred. However, they indicated that the usefulness of touch screens was limited to locating the cursor. Operators indicated that the CRT based control panels introduced some challenges to get "at–a-glance" status of the operating units as compared with the manual control panel. With use and training, however, they had come to prefer the CRT based systems. They also indicated that greater quantities of data could be viewed from the CRT based panels than was available from the manual control panels.

Monitoring of processes from remote or back-end control rooms started in the remote area control rooms. It had since been relocated to the main unit control room. Unit Operators had auxiliary operators available to assist with unit control. Like Bonanza, they indicated that the added responsibility of monitoring back-end and outer area operation from the main control room had not impeded their ability or quality of control. They attributed this to the improved control capabilities of the new DCS systems and the increase in available data to the operator through the new systems.

Similar to Bonanza, the new systems increased both information and control capabilities. System support personnel indicated that the installation of a simulator prior to the DCS/DAS system would have allowed valuable pre-replacement training for operations personnel.

An operations person was utilized to configure the controls and information displays (See attached examples.). Both operations and technical personnel indicated that this was a very successful and recommended method. This person was later designated as the DAS administrator and the primary authority for screen changes and construction. Display design followed largely the Foxboro face-plate style. Touch screens were installed, but operators preferred the mouse and keyboard interface.

The DCS controls changes and administration was completed by the two (2) systems technicians. They were originally from the I&C department. The three (3) systems support personnel formed a defacto IA systems support group. Foxboro was also retained under maintenance contract for additional system maintenance support. There are currently no plans to rotate support other personnel through the DCS/DAS system support group.

Navajo personnel were pleased with the new Foxboro IA systems and with Foxboro support. They indicated that both installation project support and post installation support have been very satisfactory.

Attachment # 4 - Alternative Project Schedules

## DCS Replacement Timetable w/ Accelerated Simulator Schedule

| Calendar Year | ** Denotes Approximate Date of Annual Major Outage* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2000 Jul / 2001 Jan | Jul / 2002 Jan | Jul / 2003 Jan | Jul / 2004 Jan | Jul / 2005 Jan | Jul / 2006 Jan | Jul / 2007 Jan | Jul / 2008 Jan |
| Budget Year | FY2000-2001 | FY2001-2002 | FY2002-2003 | FY2003-2004 | FY2004-2005 | FY2005-2006 | FY2006-2007 | FY2007-2008 |
| FOX 1/A Replacement Schedule | Continued Technology investigation | Complete preliminary engineering, budget, and develop project specifications, issue RFP, Select Vendor. | [redacted] | [redacted] | *Alternative Deferred Schedule - Project completion in 2004-05* | *Alternative Deferred Schedule - Project completion in 2005-06* | *Alternative Deferred Schedule - Project completion in 2006-07* | 12/31/07<br>New NOx Requirements on 12/31/2007 Replacement must be completed prior to NOx deadline. |
| Accelerated Simulator Replacement Schedule | | Budget/Spec for Simulator | [redacted] | [redacted] | [redacted] | | | |
| CCS, Turbine, BFP, and Burner Managment Systems Replacement Schedule | | | *Accelerated Replacement Schedule - Accelerated 2 years.*<br>Beginning of controls replacement could be accelerated to this point with the delivery of a turn-key simulator system. | *Accelerated Replacement Schedule - Accelerated 1 year.*<br>Controls expansion, coordination w/DAS replacement, or CCS reliability problems may require acceleration of replacement.<br>Replacement must be completed prior to NOx deadline. | Budget for CCS, GE, Bailey, BFP, and SER replacement systems hardware. | [redacted] | [redacted] | |

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# DCS Replacement Timetable w/ DCS Schedules

Calendar Year — * Denotes Approximate Date of Annual Major Outage

2000 Jul | 2001 Jan | Jul | 2002 Jan | Jul | 2003 Jan | Jul | 2004 Jan | Jul | 2005 Jan | Jul | 2006 Jan | Jul | 2007 Jan | Jul | 2008 Jan

| | Budget Year | FY2000-2001 | FY2001-2002 | FY2002-2003 | FY2003-2004 | FY2004-2005 | FY2005-2006 | FY2006-2007 | FY2007-2008 |
|---|---|---|---|---|---|---|---|---|---|
| ACCELERATED 1 YR | **FOX 1/A Replacement Schedule** | Continued Technology investigation | Complete preliminary engineering, budget, and develop project specifications, issue RFP, Select Vendor. | [redacted] | [redacted] | *Alternative Deferred Schedule - Project completion in 2004-05* | *Alternative Deferred Schedule - Project completion in 2005-06* | | ⇧ 12/31/07 New NOx Requirements on 12/31/2007 Replacement must be completed prior to NOx deadline. |
| | **Accelerated Simulator Replacement Schedule** | | Budget/Spec for Simulator. Budget for delivery of controls logic for CCS, GE, Bailey, BFP, and SER systems. | [redacted] | Operator Training | | | | |
| | **Accelerated Controls Replacement Schedule** | | | *Accelerated Replacement Schedule - Accelerated 2 years.* | Budget for CCS, GE, Bailey, BFP, and SER replacement systems hardware. | [redacted] | [redacted] | | |
| ACCELERATED 2 YRS | **FOX 1/A Replacement Schedule** | Continued Technology investigation | Complete preliminary engineering, budget, and develop project specifications, issue RFP, Select Vendor. | [redacted] | [redacted] | *Alternative Deferred Schedule - Project completion in 2004-05* | | | ⇧ 12/31/07 New NOx Requirements on 12/31/2007 Replacement must be completed prior to NOx deadline. |
| | **Accelerated Simulator Replacement Schedule** | | Budget/Spec for Simulator. Budget for delivery of controls logic. | [redacted] | Operator Ttraining | | | | |
| | **Accelerated Controls Replacement Schedule** | | | Budget for CCS, GE, Bailey, BFP, and SER replacement systems hardware. | Purchase and Install U2 CCS, GE, Bailey, BFP, and SER replacement systems. | Purchase and Install U1 CCS, GE, Bailey, BFP, and SER replacement systems. | | | |

# MASTER PLAN
## DCS Replacement Project

**I. Project Purpose, Scope, & Objectives.**

A. DCS Project Purpose

The purpose of the DCS replacement project is to:

1. Address the problem of obsolescence in critical plant process control and data systems; and
2. To coordinate approval and implementation of that master plan.

B. Project Scope

The project scope includes modernization and, if required, replacement of the Intermountain Generation Station (IGS) Coordinated Control Systems (CCS), Process Information Computer (PIC) systems, and the IGS Simulator (SIM) system. A list of subordinate systems to each of these area major system category is provided below.

1. CCS:
    - a. Foxboro Videospec and Microspec systems
    - b. GE Turbine Automatic Controls (TAC), Turbine-Generator Supervisory Instrumenation (TGSI), and Electro-Hydraulic Control systems
    - c. Rochester Information System (RIS)
    - d. Bailey burner control systems.
2. PIC Systems
    - a. FOX 1/A computer systems
    - b. PI Plant Information Systems

3. IGS Controls Simulator - Training and Controls Testing System

C. DCS Project Objectives

1. Authorization: Obtain approval for the DCS Master Plan and multi-year capital projects.
2. Procurement: Develop replacement specifications, Request proposals from qualified vendors, and select the replacement systems following approved procurement procedures.
3. Implementation: Install, test, and implement replacement systems per the approved replacement schedule.
4. Finalization: Complete project documentation and close-out procedures.

## II. Proposed Replacement Sequence

It is proposed that replacement of the IGS process data and control systems be implemented pursuant to the following sequence and schedule.

A. Sequence

The sequence below represents a "phased" replacement approach. Replacement is recommended as follows:

1. FOX 1/A Systems
2. Simulator
3. CCS, Turbine, BFP, and Burner Management Controls; Sequence of Events Recorders; and, Overall Systems Optimization
4. Sootblower Control Systems

Replacement will begin with the information system which currently suffers from the highest failure risk. This allows improvement to the data collection side of the DCS systems. These enhancements will assist in building accurate models of the generation units for the simulation and control systems to identify improvements in the controls logic.

Replacement of the information systems is followed by installation of a simulation system. Installation of a simulator at this stage is recommended for the following four (4) reasons:

a. An accurate model of the generation units can be constructed in advance.
b. The simulated models of the generating units can be used to pre-test and correct the controls logic.
c. Operators and other appropriate support personnel can be trained to use and become expert in the operation and familiarity with the replacement control systems prior to their installation.
d. Tested control loops, upon which personnel will have been trained, will be loaded on the live systems during installation.

With pre-tested controls logic and pre-trained operators, simultaneous replacement of major controls and SER systems on a unit by unit basis is recommended. This will minimize the long-term impact of migration and amount of custom configuration required to support compatibility between new and old systems. It will also maximize the benefit of advanced operator training.

B. Schedule

It is proposed that the systems replacement be implemented in four (4) multi-year capital projects following the schedule outlined on the following page.

## DCS Replacement Timetable

Affected Systems:

- Process Information Systems: FOX 1/A
- Coordinated Control Systems: CCS (Videospec, Microspec)
- Turbine Control Systems: GE Systems (EHC, TAC, TGSI)
- Burner Management Systems: Bailey Systems
- Sequence of Events Recorder Systems: SER (Rochester Information System)
- BFP Control Systems: MDT20
- Sootblower Control Systems: Diamond Power

| Projects | FY2001 | FY2002 | FY2003 | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 |
|---|---|---|---|---|---|---|---|---|
| FOX 1/A | Continued Technology Investigation | | | | | | | |
| Simulator | | Budget/Spec for Simulator | | | | Deferability contingent on Control System Replacement Schedule | | |
| CCS, Turbine, BFP, and Burner Managment Systems | | | | Budget/Spec CCS, GE, Bailey, BFP, and SER replacement systems. | | | Replacement must be completed prior to NOx deadline | |
| Other Systems | Replace U1/U2 Sootblower Systems | | | | | | | New NOx Requirements on 12/31/2007 |
| **Preliminary Cost Estimates** | | **$40K** | **$1,495 K** | **$115 K** | **$1,265 K** | **$1,265 K** | **$200 K** | **$200 K** |

## III. Master Plan Foundation

This section of the DCS Replacement Project Master Plan provides information on each of the systems included in the project. This information describes the current status of each system and identifies the foundation for the master plan recommendations. The information in this section is presented on a system by system basis.

### A. FOX1/A

#### 1. System Status:

a. The FOX 1/A Was Retired From Sale In 1989

The IGS FOX 1/A systems are Foxboro Spectrum Technology that were installed in 1985-86 at IGS. Foxboro retired the Spectrum product line from production in 1990. It guaranteed support for the Spectrum system indefinitely. However, Foxboro has since transferred primary support for Spectrum products to a third party vendor. Primary OEM support is contracted through PCS.

b. FOX 1/A Component Failure, Quality, and Availability Issues

The FOX 1/A systems are experiencing increasing rates of failure with system components. This is due to the length of time system parts have been in service and a degradation in quality of some replacement parts. Time in service increases the sensitivity of system components to damage from normally harmless occurrences such as the minor power spike from powering down and re-powering a system. Additionally, the FOX 1/A systems face availability issues with some components. Some spare parts have been discontinued from production. This is the primary cause of the availability and quality problems faced by FOX 1/A system owners and spare parts suppliers. Replacements for discontinued units are limited to either repaired or "replacement in kind" spares.

c. Increasing Problems for Support of Spare Parts

Discontinued/repaired units sometimes require repair with refurbished components. This increases repair lead time and frequently introduces quality problems with replacement units. Parts that are "Replacement In Kind" (RIK) units, when available, include new technology components adapted for use on the Spectrum systems. These components are generally of high quality and reliability. However, given the size of the installed base of the FOX 1/A systems, production runs for RIK parts are generally small which increases lead time requirements and cost. Additionally, some of these units have now been in service long enough to face the problems of obsolescence.

With the FOX 1/A, implementation of some RIK units present additional complications. New methods and tools for use, calibration, and configuration of RIK units are frequently required. In the case of FOX 1/A disk drives, which were discontinued from production and must now be replaced with RIK units, new storage media (disks) must be purchased which are compatible with the replacement units. Sufficient quantities must be purchased to accommodate all data that has been stored for the FOX 1/A

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systems. Additionally, sufficient man-power must be dedicated to transferring data from the old media to the new media while the old disk remain operational.

The table below lists critical systems components facing the repair and supply problems listed above.

| Component | Qty | Problem(s) | Remedy | Timetable |
|---|---|---|---|---|
| Bulk Storage Memory (CORE) | 4 | No longer manufactured. No Spares. Current 3rd party replacement is obsolete. | 3rd party replacement. | Two (2) have been replaced. Remaining two (2) will require replacement within two years. |
| Removable Disk Drives | 8 | No longer manufactured. No Spares. | 3rd party replacement. | Two (2) have been replaced. The remaining 6 drives will require replacement within two to three years. |
| Fixed Disk Drives | 4 | No longer manufactured. No Spares. | 3rd party replacement. | Required in two years |
| System Terminals | 4 | No longer manufactured. No replacement units. Some spare parts and consumable availability problems. In house repair until while spare parts available. | None. | Unknown. |
| Alarm Printers | 4 | No longer manufactured. Some spare parts and consumable availability problems. In house repair until while spare parts available. | 3rd party replacement w/ interface to PC for alarm archival. | Unknown |
| High Speed Printers | 4 | No longer manufactured. Some spare parts problems. | 3rd party replacement w/ adapted laser printer. | Laser printer adapted. 4 |
| Control Panel/Console CRTs | 26 | No longer manufactured. No 3rd party replacement currently available. | Limited quantity of spares from adapted Simulator CRTs. 3rd parties working on a adapter for VGA screens. | Spares likely to last three to five years, then replacement will be required. |

d. <u>Declining Support Expertise</u>

The FOX 1/A and all Spectrum products face the "Brain Drain" issue. When the FOX 1/A was retired from the Foxboro sales line, personnel with expertise in the development and support of that system have gradually been reassigned to work on other systems. As the balance of installed Foxboro equipment has shifted from the FOX 1/A to newer technology systems, the number of persons with FOX 1/A knowledge has diminished as well as the level of experience on that system. IPSC personnel frequently encounter FOX 1/A problems with which available outside technical support can provide only a skeletal amount of technical support or where such support may be fully reliant on technical manuals rather than existing knowledge and experience. This presents a cost of ownership to IGS in terms of FOX 1/A availability as troubleshooting and repair times increase.

e. Cost of Lost Data

With the expansion of the Process Information Computer capability at IGS, the useable models of performance have increased exponentially in power and complexity. The FOX 1/A systems and associated Spectrum I/O components supply a significant portion of the process data to these models. The data was first used to develop the models. It is now evaluated by them. Failures of the FOX 1/A system components, long or short, result directly in the introduction of inaccuracies in the measurement of generating unit performance and evaluation of the actions of persons operating the generating units.

As the capabilities of the tools used to evaluate and predict unit performance have increased, so too has IGS observed an increase in the demand and reliance upon those tools to make operating decisions that affects both performance and availability levels. Inaccuracies or failures of this system bring more immediate and measurable consequences. Additionally, the integrity of the data will increase in value as it is used by IGS to identify the causes of failures and methods of failure prevention of generating unit components. It will also serve as an increasingly important vehicle to record due diligence by IPSC in the proper operation of the generating units and compliance with regulatory requirements.

Finally, with the increasingly competitive nature of the power industry, greater flexibility and capacity is required from each generating station. This is true whether a given station is implemented in direct competition with other suppliers on the power market or providing the base load that supports that competition. The more accurately the operation of a unit can be understood, measured, monitored, and predicted by the entity operating that unit, then the more valuable tool it will be in the competitive market.

f. Trends

Given the current trends for component failure versus reliability of the FOX 1/A systems at IGS, within three (3) to five (5) years, IPSC could face a serious challenge in its ability to keep the FOX 1/A system operating on even a provisional basis. While exact support and system failure dates and times cannot be accurately predicted, intermittent failures currently experienced can be expected to increase at their present rate. With each effort to repair a failed system comes an increasing likelihood that such repair efforts precipitate further failures of sensitive system components. Such a pattern was observed with the IGS Simulator. A similar pattern is emerging on the FOX 1/A systems.

2. **Recommendation for FOX 1/A Systems:**

Replacement is recommended following a three (3) phase, multi-year capital project.

Phase 1: Fiscal Year 2001-02

a. Complete preliminary system engineering.
b. Complete investigation and define preferred technology for DCS replacement systems.
c. Develop FOX 1/A replacement specification.
d. Requests replacement proposals from DCS equipment vendors.
e. Evaluate proposals and select vendor.

Phase 2: Fiscal Year 2002-03

f. Purchase FOX 1/A replacement system for Unit 1.
g. Receive, stage, and pre-test the U1 system.
h. Complete training for support personnel and system users on tested system.
i. Complete full installation during four (4) week U1 outage.

Phase 3: Fiscal Year 2003-04

j. Continue system training.
k. Receive, stage, and pre-test the FOX 1/A replacement system for Unit 2.
l. Complete full installation during the four (4) week U2 outage.
m. Complete project close out and documentation.

**3. Conclusion**

While there is an instinct to continue to extend the service life of the FOX 1/A systems to the absolute end of OEM or third party support, such an action would likely result in a serious and extended breach in the availability of measured process data and succeeding analytical and predictive data. Given a three (3) to five (5) year failure estimate, full replacement is recommended within three (3) years.

B. SIMULATOR:

**1. System Status:**

a. No System Currently Available

Currently there is no Simulation System.

b. Simulator Benefits Realized Prior to Controls Installation

...

2. **Recommendation for Simulator**
It is recommended that the installation of the Simulator precede the Control System replacement by two years to allow for proper configuration and testing of the system, and to provide adequate training time for personnel with unit operations duties.

C. Turbine Controls, CCS, Burner Management, & SER
1. Turbine Controls:
a. System Status:
b. Recommendation for Turbine Controls

2. CCS:
a. System Status:
b. Recommendation for CCS

3. Burner Management:
a. System Status:
b. Recommendation for Burner Management

4. SER:
a. System Status:
b. Recommendation for SER

B. Other Systems
1. Soot Blower:
a. System Status:
b. Recommendation for Soot Blower

## II. Master Plan Implementation
A. Project Authorization
1. Prepare a Capital Project Budget proposal(s) per approved DCS Master Plan.
2. Present proposal to to IPSC staff for approval.
3. Present to LADWP for project approval.
B. Project Implementation (Completed following approved sequence through multi-year capital project(s).

1. FOX 1/A Replacement
2. Simulator Replacement
3. Control Systems Replacement
4. Final Controls Modifications for NOx Compliance

C. Project Conclusion
1. Formalize system documentation
2. Formalize user documentation.
3. Formalize plant controlled drawing modification.
4. Complete project closeout.

**ADDENDUM 1 - FOX 1/A Replacement Multi-Year Project**

Project to include the following steps and purchases:

Phase 1: Fiscal Year 2001-02

Complete preliminary system engineering.

I. Complete investigation and define preferred technology for DCS replacement systems.
  - A. Prepare conversion descriptions
  - B. Final System research
  - C. Prepare Detailed Replacement Specifications for the FOX 1/A Computer Systems

II. Initiate Procurement and Pre-Installation Activities
  - A. Release Requests For Proposals (RFPs) to DCS equipment vendors.
  - B. Evaluate proposals and select vendor.
  - C. Begin pre-installation activities.

III. Costs for Phase 1.

| | |
|---|---|
| System Engineering and pre-installation work: | \$20,000 |
| Outside Services & Training: | \$20,000 |
| TOTAL | \$40,000 |

Phase 2: Fiscal Year 2002-03

Complete installation and configuration of the FOX 1/A replacement system for Unit 1.

I. Complete pre-installation work
  - A. Prepare FOX 1/A database and critical programs for conversion.
  - B. Manufacture of systems.
  - C. Factory Acceptance Testing.
  - D. Preliminary training of system engineers and support personnel

II. Complete pre-outage installation and training.
  - A. Install processor hardware.
  - B. Convert U1 FOX 1/A database and convert critical programs.
  - C. Pre-configure new system
    1. Build U1 point databases.
    2. Build graphics.
  - D. Complete training for support personnel and system users on tested system.
  - E. User Training.

1. Staff and Management.
2. Unit Operators.
3. Control Operators.
4. Operations Supervisors.
5. Engineers.
6. Maintenance & Planning personnel
7. Other Users.

F. Complete full installation during four (4) week U1 outage.

1. Replace i/o connections.
2. Install final i/o device to system communications.
3. Wring-out i/o configuration (QA/QC)
4. Final System QA/QC prior to releasing system for live use.

G. Go Live

III. Costs of Phase 2

| | |
|---|---|
| System Hardware & Software: | $575,000 |
| Systems Engineering | $ 25,000 |
| Contractor Labor | $ 30,000 |
| Installation Labor | $ 40,000 |
| Training | $ 75,000 |
| Travel | $ 50,000 |

<u>Phase 3: Fiscal Year 2003-04</u>

Complete installation and configuration of the FOX 1/A replacement system for Unit 2.

I. Complete pre-installation work

A. Continue system training.
B. Prepare FOX 1/A database and critical programs for conversion.
C. Manufacture of systems.
D. Factory Acceptance Testing.
E. Preliminary training of system engineers and support personnel

II. Complete pre-outage installation and training.

A. Install processor hardware.
B. Convert U2 FOX 1/A database and convert critical programs.
C. Pre-configure new system

1. Build U2 point databases.

2. Build graphics.

D. Continue training for support personnel and system users on tested system.

E. Continue User Training.

F. Complete full installation during four (4) week U1 outage.

1. Replace i/o connections.
2. Install final i/o device to system communications.
3. Wring-out i/o configuration (QA/QC)
4. Final System QA/QC prior to releasing system for live use.

G. Go Live

III. Costs of Phase 2

| | |
|---|---|
| System Hardware & Software: | $575,000 |
| Systems Engineering | $ 25,000 |
| Contractor Labor | $ 30,000 |
| Installation Labor | $ 40,000 |
| Training | $ 25,000 |
| Travel | $ 10,000 |

TOTAL COST ESTIMATE:

| | 2001-2002 | 2002-2003 | 2003-2004 | TOTALS |
|---|---|---|---|---|
| Engineering Costs | $20,000.00 | $25,000.00 | $25,000.00 | $70,000.00 |
| Installation Costs | $0.00 | $125,000.00 | $75,000.00 | $200,000.00 |
| Contractor Costs | $20,000.00 | $30,000.00 | $30,000.00 | $80,000.00 |
| Material | $0.00 | $575,000.00 | $575,000.00 | $1,150,000.00 |
| Job Total | $40,000.00 | $755,000.00 | $705,000.00 | $1,500,000.00 |

**IV. Cost Evaluation of Replacement**

Initial Cost: $575,000 per unit

Present Value = $575,000

Annualized Value $_{(A/P,\ 6.38\%,\ 10yrs)}$ = $79,536

Current Average Cost of Maintenance Per Unit = $42,000

TRAINING COST TABLE

| Description | Cost | Qty | Totals |
|---|---|---|---|
| Intro | $4,000.00 | 2 | $8,000.00 |
| Equipment Maint. $2000 x 10 | $2,000.00 | 18 | $36,000.00 |
| System & Software Maintenance: $2000 x 10 | $2,000.00 | 18 | $36,000.00 |
| I/A Ethernet Maintenance: $2000 x 10 | $2,000.00 | 18 | $36,000.00 |
| 50 Series Admin $1400 x 2 | $1,400.00 | 2 | $2,800.00 |
| Apps Programming $2000 x 2 | $2,000.00 | 2 | $4,000.00 |
| Connoisseur $2000 x 2 | $2,000.00 | 2 | $4,000.00 |
| Fox Scada $4000 x 2 | $4,000.00 | 2 | $8,000.00 |
| Remote Station Config & Maint. $2000 x 2 | $2,000.00 | 18 | $36,000.00 |
| Total | | | $170,800.00 |